SCHOOL SCIENCE AND MATHEMATICS

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THE GREAT SIBERIAN TEACHER

The U.S.S.R. celebrates this year. The cause is not a great economic or military victory but the centenary of the birth of a man who has had more influence on the progress of mankind than any of the Czars or military leaders of all the Russians. On Feb. 7, 1834, Dmitri Ivanovich Mendeléeff, the seventeenth child in a poverty-stricken family, was born at Tobolsk beyond the Urals. Illness and misfortune impeded his progress but did not prevent him from getting a college education.

He graduated from the University of St. Petersburg at the age of twenty-two and thirteen years later became professor of chemistry there. During the twenty-four years in this position most of his creative work was done. Here the Periodic Table took form. The discovery of three new elements—gallium in 1871, scandium in 1879, and germanium in 1886—followed closely his prediction of their existence and probable properties. In the field of physical chemistry he made a careful study of solutions and change of state.

Out of chaos he built a systematic chemistry. What a jungle the student of chemistry would be in did he not have the periodic table of elements! By means of it Mendeléeff became the greatest teacher of chemistry of all time. By its use new elements have been discovered and errors in previous experiments were detected and corrected. Hundreds of modifications and additions have been made to the periodic table but its framework stands. If the position of an element is given, its main properties are at once known. His lecture room was always thronged with students. He could stimulate and inspire. Mendeléeff, the man, died Feb. 2, 1907. Mendeléeff, the teacher, carries on.

PREVIEW OF THE 1934 CONVENTION

The annual convention of the Central Association of Science and Mathematics Teachers will be held at the Hotel Lincoln, Indianapolis, Nov. 30 and Dec. 1, 1934. The following is a preview of the *GENERAL* program.

Dr. Otis W. Caldwell, Teachers College, Columbia University will be Toastmaster at the banquet and conduct a symposium on science teaching. The Press, publishing houses, and prominent men of science will appear on this part of the program. *The Philosophy of Science,* **Dr. W. L. Beauchamp,** University of Chicago. *Trends in the Reorganization of Science and Mathematics in the Secondary Schools,* **Dr. J. E. Stout,** School of Education, Northwestern University. *Can Man's Group Activity be Measured?* **Dr. H. C. Davis,** Indiana University. *The Conservation Policy of the United States Government,* **Dr. H. C. Bryant,** Ass't Director of National Park Service.

The *SECTION* officers have planned timely programs. Recent trends in methods of presentation and subject matter content will be presented. There will be papers by specialists in each line. The following leaders in education are among the speakers:

Ellis Persing, Western Reserve University, **H. C. Bryant,** National Parks Service, **Earl R. Glenn,** New Jersey State Teachers College, **Lillian Hethershaw,** Drake University, **Mason Hufford** and **H. C. Davis,** Indiana University, **Doctor Dyer,** Antioch College, **J. O. Frank,** Oshkosh Normal College, **Ellsworth Obourn,** St. Louis, **H. Clyde Krenerick,** Milwaukee, **Geraldine Shontz,** Indiana State Teachers College.

The local arrangements committee will make this convention one of the best ever held by the Association. *Hearty Hoosier Hospitality* is the slogan, and emphasis is to be put on the social aspect of the meeting. The local chapter of the Council of Administrative Women in Education have volunteered to help make the Friday afternoon reception a real event. A breakfast for women is being sponsored by the Indianapolis Chapter of Phi Lambda Theta. Special entertainment is being planned for wives of members.

Educators have long recognized the influence of Central Association in furthering the cause of science and mathematics teaching and teachers. Many teachers owe their professional awakening and consequent advance in position to the stimulus of this Association and its Journal. The contacts made and the friendships formed as a result of regular attendance of the conventions held annually in nearby cities have been an inspiration to many. For over thirty years excellent programs have been given, and the official journal, SCHOOL SCIENCE AND MATHEMATICS, enjoys an enviable circulation. ***Every ambitious teacher should join the Associa-***

tion and receive the benefits thereof. We invite you to become a member now. We need your presence at the meetings; your contributions to the Journal; your membership fee. We believe you need our fellowship; our magazine; our meetings and programs; our organization. SEND IN YOUR MEMBERSHIP APPLICATION NOW!!

Katharine Ulrich, *President*

DO NOT READ THIS

(if you are a member of the Central Association of Science and Mathematics Teachers)

Do you realize that for the price of membership in the Central Association of Science and Mathematics Teachers you receive (1) a year's subscription to the Journal, (2) a membership card which will admit you to the Annual Meeting, and (3) the professional advantage of having your name on the membership list of one of the most progressive professional organizations in the middle west?

This membership list is published in the Association's *Year Book* which has a circulation of 6000. In order for your name to appear in the *1934 Year Book,* your remittance must be in the hands of the Business Manager of the Journal on or before October 15th. In this case you will receive your membership card by mail. Membership cards for which the remittance is received later, will be distributed at the convention. Persons who are now subscribers to the Journal but not members of the Association may become members by so indicating when they renew their subscriptions.

Marie S. Wilcox, *Chairman Membership Committee*

Application for Membership
in the
Central Association of Science and Mathematics Teachers, Inc.

Date . . . . 19 . . . . . .

I, ..., hereby apply for membership in Central Association of Science and Mathematics Teachers, Inc., and inclose $2.50 as annual membership dues, $2.00 of which is for a year's subscription to SCHOOL SCIENCE AND MATHEMATICS.

Name . . . .
Last Name First Name

School Address . . . .
School City State

Home Address . . . .
(only if school address is not to be used) Street City State

Check Section in which enrollment is desired: *Biology, Chemistry, Elementary Science, General Science, Geography, Mathematics or Physics* . . . .

Mail this application with $2.50 (Foreign countries $3.00) to W. F. Roecker, 3319 N. 14th St., Milwaukee, Wis.

A SENTENCE WORTH READING

On one of the walls of the basic science section of the Hall of Science, A Century of Progress International Exposition, there may be found a number of sentences relating to science—some thoughts of great men of the past. One of the sentences stands at the top of the Contents page of this issue. Do you read the sentence at the top of that page of each issue? Some of them are gems of thought from the masters of the past; some have been extracted from current publications, and some come from our contributors.

"He who would not be forgotten as soon as he is dead must either do something worth writing or write something worth reading." Why not try your hand at writing one sentence that will express a great scientific truth? Send it in. A page of them will be worth framing.

SCHOOL TEXTBOOKS

The textbook is recognized as an important tool in all branches of study. Recently children have been handicapped by lack of up-to-date books. In order to cut expenses boards of education have decreased or eliminated the appropriation for new books with the result that children are forming careless habits of study because they have no definite text assignments; they are getting wrong impressions from studying obsolete books; they are acquiring numerous diseases from filthy, germ-laden old books.

Certainly this condition is the result of false economy. A recent N.E.A. survey shows that in 1934 less than 1% of the total expenditure for education will be for books. Parents on the average give their children far more money to spend for movies and chewing gum than for school books and supplies. In our attempt to return to normalcy in education let's not forget the textbook situation.

AMENDMENTS TO THE BY-LAWS OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS

At the next regular meeting of the Association, the following Amendments to the By-Laws will be presented.

Part III, Section 1. *Officers.* The officers of this association shall be a President, a Vice-President, a Secretary-Treasurer. One or more Assistant Secretaries and Assistant Treasurers may be appointed by the President.

Part III, Section 4. *Powers and Duties of Officers.*

(c) Secretary-Treasurer: The Secretary-Treasurer shall keep all records. He shall record the minutes of all meetings. He shall carry on correspondence of the Association under the direction of the Executive Committee. He shall collect membership dues. He shall give a detailed report at each meeting of his receipts and disbursements. He shall pay out funds on the order of the Board of Directors and the Executive Committee.

TEACHING SCIENTIFIC METHOD

Article V: Why Science in the Elementary School

By Jennie Hall
Advisor in Science
Minneapolis, Minnesota

That the scientific attitude is the chief aim and should be the paramount outcome of science teaching is stated very definitely by authors of current articles upon the teaching of science. That this same attitude is most desirable as an outcome for all teaching is quite as definitely stated by authors of current articles in other fields of learning.

What is this attitude of the scientist, "the seeker of truth"? What are the steps in its growth? What experiences, what habits contribute to its development? What technics aid in its nurture? What simpler attitudes are factors of this ultimate goal; "the scientific attitude"? It has been analyzed many times, and although opinions differ in respect to the range of the characteristics, the same few elements appear in each analysis. These are the attitudes which result from habits of intellectual integrity, open-mindedness, seeking the cause for the effect, suspending judgment, and testing opinions and beliefs.

We as teachers are obligated to accomplish this goal which has been set. We must find the level at which initial steps can be taken to give the learner these desirable attitudes. Many questions of values arise to one who faces this responsibility. Some of these are here set forth.

1. *How much does scientific guidance in answering or solving the "why" question contribute to the scientific attitude?*

During our "cold waves" in Minnesota this question is often brought to primary teachers: "Why do milk bottles break when the milk freezes"?

The teacher suggests attempted explanation and experimentation. Children theorize as follows: "The milk needs more room when it freezes." They speak from experience and show a critical attitude: "The bottles do not always break; sometime the milk pushes the stoppers out of the bottles." They experiment by setting bottles of water outside, some with tight covers, some with looser covers, and some with no covers. They watch results with interest. Sometimes bottles are broken; sometimes corks and stoppers are pushed out. But always re-

sults show pressure exerted by the ice, which certainly "needs more room" than did the milk or water used in the experiment.

The spirit of experimentation rules for a time. Verifying reports come from home efforts. Children suggest other experiments. They set a pan of water outside and patiently, persistently, eagerly, watch as the ice first appears around the edge and then spreads across the top by sending long finger-like films over the water. Often they tip the pan to learn whether the ice is yet solid. Triumphantly they note the bulging upper surface; for does this not prove that ice takes "more room" than does the water which makes it?

Is this scientific attitude in embryo?

Have these children used in any degree the habits of scientific thinking?

Did they not seek for the cause and effect relationship?

II. *Do habits of accurate observation and record keeping acquired by younger children engender later development of the scientific attitude?*

Weather reports and weather calendars are devices used by primary teachers to gather data necessary for the solution of questions raised and to stimulate interest and develop skill in making and using records.

The thermometer drops 40° in less than 24 hours. A third-grade group raises the question: "Why does it get so much colder so fast"? In other words, what causes the change in weather? Children are sure that if they had kept weather reports as they had last year, they might be able to tell. They decide to record temperature, wind, and storm for a period of time. Faithfully they keep the record for a month. They summarize the data which shows in general northerly winds on cold days, southerly winds on warm days, westerly winds on clear days and easterly winds on stormy days. They generalize: "The wind makes the weather change." Some children insist on further verification through continued observation. Weeks afterwards individual children report proof of the truth or falsity of the conclusion.

Was the habit of daily observation at earlier levels the parent of a felt need for accurate data upon which to base judgment?

III. *If we are to expect the learner to develop ability to make complex generalizations, must opportunity be given at each level of learning for extended experience in simple and accurate observation with consequent simple generalizations from data?*

Children in the primary grades delight in the study of shad-

ows and of the sun. A group of kindergarten children in a sunny south room were at play with wooden animals. Each animal cast a shadow. Sometimes the shadows were one shape, sometimes another, depending upon how the animals stood in the sunshine. The game became a shadow game, not an animal game. It was the sun that made the shadow because it could not shine through the wood. It made shadows shaped like the animals. It made "funny" shadows, "fat" shadows, and "slim" shadows. Such statements accompanied by gleeful laughter evidenced the interest and joy in the game.

Another group of children, a little more experienced in school, observe that shadows of all trees fall in the same direction at the same time of day; that in the morning the tree shadows, their own shadows, and all other shadows fall toward the west. The position of the sun in the sky and the position of the shadow, together with experience, lead them to the conclusion that this is because the sun is in the east in the morning.

The teacher leads in the theorization: "How will shadows fall at noon?" "Why?" "How will shadows fall in the afternoon?" "Why?" Proof of the truth or falsity of their judgments is established by observations made at noon and in the afternoon.

As experience increases, the children question regarding seasonal change of shadows and sun. Noon shadows are longer some times than at other times. The sun does not always rise at the end of the east and west street or over the same house. The children make picture records of the position of the sun in the sky. They discover that the sun is lower in the sky and farther south of the east at the same morning hour in November than it was in October. Days grow shorter. They record the sun lower and still farther south. Someone theorizes: "When the shortest day comes, it will begin to go back again." The shortest day is a vacation day, but the record is not forgotten on the return to school. Thus the full satisfaction of success in prophetic judgment is evidenced.

The shadow of an inkwell on the teacher's desk attracts a usually troublesome boy. From the vantage point of his front seat he sees it change in position. Will this inkwell tell time and season as well as the shadow board?

The children of a fourth grade ask why Byrd chooses to leave at the beginning of winter? Radio reports inform children that while winter is approaching in Minneapolis, open air con-

certs are in vogue in New Zealand. Maps surprise children by showing them that Mr. Byrd is as far south of the equator as they are north. They question: "Why is it warmer in New Zealand than in Minneapolis?" Children assist in darkening the room, and in arranging the globe and lantern; for they have solved other problems by using the lantern for the sun. They set the globe so that the sun shines south of the equator as they know it does when winter approaches in Minneapolis. Conclusions come rapidly: "The south pole is always in the light; the days south of the equator are longer than the nights; it is the beginning of summer there; of course that is the time for Byrd to start for the South Pole."

Other troublesome problems arise as children travel around the globe to understand the work and play of other people. "Why is it so hot and dry in Arabia?" "Why is it so hot and wet in the Congo?" "Why is our noon sun always in the southern sky?" "Why is the sun in Belgian Congo sometimes in the northern sky and sometimes in the southern sky?"

A sixth-grade group studying Egypt uses the knowledge gained in lower grades regarding the sun, evaporation, and condensation, to understand the floods of the Nile; uses its knowledge of the work of running water to understand the fertile valleys and delta and the consequent life of the people.

Is the ability of the child to answer his questions of climate and customs of people in other lands at all dependent upon the familiar knowledge concerning his own environment which he gained from experience? Is the series of carefully selected experiences in observation, data accumulation, and successful simple generalization contributory to the interest and the success of the more complex problems undertaken at the higher school levels?

IV. *As children advance in nature and science experience in school, do they show growth in the scientific attitude?*

A primary child tenderly carried a sprouted grapefruit seed to his teacher. She had given him opportunity for experience in the growth of other seeds. Never did a growing thing receive greater care. Warm spring days came, when the child carefully transplanted into the school experimental garden the tiny plant with shiny waxen leaves. There the plant thrived all through the long summer vacation. Early in the fall the child carried it back to the schoolroom, for as he said, "It might freeze some night."

Questions such as the following arise among upper primary

groups: "Can you make plants grow without seeds?" Some child's mother has "slipped" geraniums. Children visit the garden and learn to make slips or cuttings. They plant bulbs, and twigs of willow. Some are placed in water so that growing roots may be observed.

"My aunt made a sweet potato grow in water; can we do that?" License to use the window sill is followed by an array of carrots, sweet potatoes, beets, and cabbages set in water or on wet blotters. Usually every vegetable grows. Frequently the observers are rewarded by seeing the cabbage develop a blossom stalk. Sweet potato vines are often transplanted to school garden and a crop harvested in September.

In the primary grades questions are raised by the unusual in the environment, sun or moon appearing red, hoar frost, snow storm, the first dandelion or butterfly in the spring, fallen catkins, the robin's nest. Problems are suggested as a rule by patterns given in school, home, or neighborhood environment. Experiments usually result in the successful solution of the question. Interest is held in ratio to success. Children check each other in accuracy of observation. Generalizations are simple because problems are simple. Discussions of results often bring out the relationships of cause and effect, such as: "The leaves grow toward the sun." "It rained and the plants are growing fast."

In intermediate and upper grades the children ask: "How deep should seeds be planted?" "What kind of soil is best for sprouting seeds?" "Can we grow cotton in Minneapolis and have it get ripe?" "Will fertilizer help seeds to sprout?" "Why is the region around the Great Lakes so fine for raising fruit?" Their questions are the expression of needs resulting from their other school activities. They experiment and they read to solve their problems. With encouragement and helpful suggestion in their search for truth few tasks are too difficult for accomplishment. If accident ruins the work of hours, they cheerfully begin again; for now they know how to do it better. They are resourceful both in suggestion and accomplishment of activity. Many groups use paper sacks and coaster wagons to haul black dirt for their gardens. A group experimented with rabbit manure for fertilizer. In every case they are critical of results and opinions.

Does the transfer in origin of the question from the unusual in the environment and the pattern given the child to the need of further

knowledge for understanding lives and customs of people indicate growth in the scientific attitude? Do the increasing complexity of problems and the development of longer continued interest in the face of accident and failure show progress?

V. *Does the very young child easily surrender undesirable attitudes and acquire those of more desirability?*

In a primary group, temperatures had been recorded daily on a weather calendar for a period of time. A child one morning reported a temperature of 20 below zero. Objections immediately arose. "It couldn't be so low." "Why not?" "Because it isn't the coldest day." "How do you know it is not?" The radio didn't say so." "The coldest day wasn't so cold." "What did the radio say?" Agreement was reached that radio reports varied from 7° to 9° below zero. The child was wrong, and the child's community had in no uncertain terms informed him of careless and inaccurate report. His desire for approval encouraged a desire to be better prepared for reports. *Are accuracy in observation and honesty in report and record first steps in the establishment of habits of intellectual integrity?*

The ground hog story comes to most schoolrooms once a year. Children make observations to establish the truth or falsity of the prophecy. Stories of black cats which cause bad luck, of darning needles which sew up mouths, toads which cause warts and other superstitions are attacked with habits of observation and by reading, and the old idea discarded in the same way that one small child discarded the Jack Frost story. "He is not a really true boy; that's just what people say."

If attitudes are acquired and not inherited, if they are reactions (desirable as well as undesirable) resulting from the individual's contacts with the environment, is not the elementary school the logical place for beginning the necessary training? Does not the environmental content of the curriculum of the elementary school offer numerous simple problems for the development of the necessary habits? Is not the spontaneous joyous interest of the small child a motivating factor which we should capitalize as well as satisfy?

Can we not save time for the learner? Can we not avoid much wrong learning and much unlearning? Can we not move more certainly toward the goal of accomplishment, a scientific attitude for every adult, if we begin our training with the primary level? Can we not as scientists, as scientific educators with the scientific attitude, scientifically develop through our ele-

mentary and secondary schools a certain and sure path to this desired end? Can we not in this way nurture a new type of purposeful youth, who will face problems with more intelligence and therefore more success; youth, who like Kipling, can say in adulthood:

> I did no more than others did,
> I don't know when the change began,
> I started as an average kid,
> I ended a thinking man.

THE WATER LENS

By Louis T. Masson
Riverside High School, Buffalo, N. Y.

In the study of refraction of light and its application to lenses, the general procedure is to make use of the regular glass lenses found in the laboratory. Prisms and other light devices and instruments are also made of glass. By inference the pupil concludes that only glass can be used for such purposes. The real facts in the matter can be brought out and proper interest stimulated by the presentation of the "water lens." The students already know that a stick appears bent in water—in other words, water is capable of producing refraction. The two ideas of water refraction and lenses can be tied up through this home-made device, which is easy to assemble and construct.

A "water-lens" can be made as follows: Place face to face, two 3-inch watch glasses, with a piece of wood the thickness of a toothpick between them *at one point.* Heat some sealing wax in a shallow pan to a little above the melting point. Dip the rim of the watch glasses in the wax a little at a time and allow it to cool after each dipping, until only a small opening remains at the point kept open by the splinter. When the rim has cooled sufficiently remove the splinter and force water into the opening until the hollow space within the glass is full. Then seal this opening with a bit of wax, making it air-tight.

To show the properties of such a lens, it can be used as a reading glass or to magnify objects. The magnification factor will run between 2 and 4 depending on the size and curvature of the watch glasses. The lens can also be used to focus the rays of the sun to ignite a match, cigarette or a piece of cloth. In order to prove that it is the *water within* the watch glasses that produced these effects, a similar pair of watch glasses without water can be set up. It will be found that none of the effects recorded will take place.

This water lens can also be used to take pictures in place of the regular glass lens of a camera. It is most easily adapted to a Graflex camera but since few schools have them, a kodak or box camera would have to be used. With a little ingenuity, a teacher could apply the water lens to either of these, and could obtain pictures equally as good.

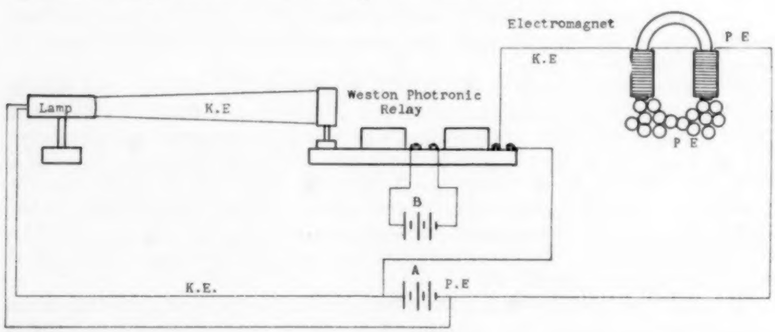
A rather unique effect can be obtained with the water lens if it is made to have a fairly large air bubble inside. When placed flat on a table, the air bubble will be at the top of the lens. The portion of the lens beneath it will be *thinner* than the rest—in other words you will have a concave lens surrounded by a convex lens. When held above a page of reading matter in this position, an enlarged view of the printing will be found to surround a reduced, distant view of that in the center.

ENERGY FORMS AND CHANGES

By H. R. Fisher
Sunbury High School, Sunbury, Ohio

For the student in elementary physics it may be hard to conceive clearly the meaning of the term energy and to grasp the fact that energy is a thing which is changeable and exists in a variety of forms. That there is energy in a stick of dynamite or a gallon of gasoline he may readily agree but for him to see that light is a form of energy or that magnetism may be classed as such is not so easy. So to demonstrate some of these unusual forms of energy and to show that they may be converted from one form to another, the following experiment was devised.

A Weston Photronic Relay, No. 607, using a photronic cell as the light-sensitive part and a minature galanometer relay and a power relay to increase the current was used. This outfit comes conveniently mounted with binding posts clearly marked for the relay circuit and the power circuit.



This apparatus was set up at one end of a table and a light operated by a storage battery focused on the photronic cell. At the other end of the table a large electromagnet capable of lifting at least thirty pounds was mounted. The same storage battery that operated the light furnished current for the magnet. The circuit to the magnet was controlled thru the power relay and this in turn was controlled by the beam of light falling on the photronic cell.

The connections on the relay were arranged so that the current was turned on in the magnet when the light shone on the cell. With this light on and the magnet energized, a quantity of steel balls were suspended from the poles of the magnet and,

of course, when the light was extinguished they dropped off because of the breaking of the circuit at the relay. Thus it was possible to magnetize or demagnetize the electromagnet merely by turning the light off or on, which indicated to the student that the light must be either the source of the power or have a control over the power.

In order to make the energy changes clear cards bearing the letters "P. E." or "K. E." were attached to the battery, connections and magnet as shown in the diagram. Then it was explained that the storage battery (A) was the source of the potential or stored energy for the demonstration. This energy was changed to the kinetic energy of light in the lamp. This kinetic energy was then converted into the kinetic energy of electricity generated by the photronic cell which operated the relays thru battery (B) and so controlled the flow of kinetic energy in the the form of electricity from the storage battery (A). This kinetic energy was then transformed into the potential form of magnetism in the electromagnet and finally this potential energy of magnetism imparted potential energy to the steel balls by holding them up against the pull of gravity. So it was possible to show that the stored potential energy of the battery passed thru all these transformations to appear finally as the potential energy of position. Electrical energy, resulting from chemical action had been caused to change into mechanical energy.

This demonstration was found to be not only quite interesting to the students but literally put energy changes right before their eyes. They actually saw that the potential energy of the storage battery was producing all the effects and that it finally reappeared as stored energy but in another form.

CLAIM TO DISCOVERY OF BOHEMIUM, "HEAVIEST ELEMENT," ALL A MISTAKE, DECLARES YUGOSLAVIAN SCIENTIST

There is no super-heavy element called bohemium. Announcement made last month, when the supposedly new substance was first reported by Dr. O. Koblic, was premature, now declares the Yugoslavian scientist.

In a recent issue of *Nature* Dr. Koblic withdraws all claims to the discovery.

The tiny speck of yellow powder obtained from pitchblende, a common source of radioactive material like radium, was not a new element. It was simply the metal tungsten, declares Dr. Koblic, like that found in the small wires inside electric lights. But the tungsten was in a form not easily identified.

OBJECTIVE TESTING IN SECONDARY SCHOOL MATHEMATICS*

By Laura Blank
Hughes High School, Cincinnati, Ohio

The term "traditional" or "essay" examination or test applies to quizzes of the sort exclusively employed until approximately the time of the Army Alpha Test, and later. In fact the essay type is still largely used. It consists of exercises in which pupils are asked to outline, discuss, summarize, state, etc.—examinations requiring a considerable amount of writing, producing results wide and varied in scope and hence relatively subjective in scoring.

The objective test or examination differs from the traditional or essay style test in that each item or task or question of it requires one specific unequivocal answer. The objective test requires a large number of specific responses, in other words, it employs a wide sampling of the field of the subject matter. The test is objective in that responses are definite and unequivocal. The grading of the paper can be made entirely impersonal in the truly objective test. Because of all of these traits the objective test produces more accurate scores and tends to serve to be prognostic, diagnostic and remedial in character.

Objective tests are classified in three large groups—personality tests, intelligence tests and achievement tests. The first group is of interest chiefly to psychologists and psychiatrists, the latter two types, of interest to psychologists and educators. This discussion will confine itself to achievement tests and, in so far as is possible, to achievement tests as applied to secondary school mathematics. Whereas an intelligence test attempts to rate the capacity to do, an achievement test attempts to get at that which has been done in a given assigned prepared task.

Objective achievement tests are of two sorts, that is standardized and informal. The term "standardized" is applied to a measuring instrument which has been scientifically constructed and made use of in a sufficiently large number of cases to establish validity and reliability, that is, a test for which one may predict results. Most of the standardized tests have been published and may be purchased, or have been but are no long-

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* Paper read at the Mathematics Section of the Convention of the Southwestern Ohio Teachers' Association, Oct., 1933.

er commercially available as they have been supplanted by better tests constructed more recently. The term "informal" objective or informal new-type test in this paper, shall be construed to apply to tests or exercises or examinations constructed by a teacher, or a group of teachers, for a local situation, calling for brief pupil responses, which makes use of the forms and methods of scoring of standardized objective tests, but such tests as have not been applied to large numbers of pupils, tests which have not gone through extensive trying out and experimentation with subject matter from various textbooks, and moreover tests which are not available from a publisher. In general, an informal objective test does not represent as refined an instrument of measurement as standardized objective tests.

Our interest is then in objective tests as applied to the mathematics of the high school. Though standardized tests will be considered, the chief interest will be in the applicability of informal objective testing methods to the various branches of mathematics.

In a brief paper it is not possible to discuss fully the arguments pro and con as to objective testing or as to the essay type of test. The chief arguments in favor of the objective or new-type test are its objectivity, obviously, and its extensive sampling and the fact that it permits of very little opportunity for bluffing on the part of the pupil. The chief arguments in favor of the essay type of examination or test are its endeavor to explore depth of understanding and also its emphasis upon the use of the mother tongue, its requirement of good use of one's language, paragraphing, punctuation, idiomatic usage, etc. However there are educators who refute all of these arguments and many more. The arguments and refutations on the subject are, in fact, suggestive to the novice in objective test designing. They forewarn one of many of the pitfalls in the construction of informal objective tests.

Then assuming that for certain topics of some of the subjects of high school mathematics objective testing is desirable it may be noted that there are a dozen or more standardized tests for algebra, some prognostic, other diagnostic, prepared in series and in two or three forms, with manuals, keys and class record forms. Some, planned for prognosis, are to be taken before the pupil enters upon his work in algebra, intended to retain or eliminate him from attempting the subject. Others are to be taken at the end of the first semester, with this same general

object, and also for diagnostic purposes. Another group, scaled, is to be taken at intervals throughout the year for the purpose of rating work and also for diagnosis. There are as many standardized tests and of the same types for plane geometry. For the more advanced branches of high school mathematics there are the "American Council Test in Solid Geometry," and the "American Council Trigonometry Test," as well as some others in preparation. There are, too, a number of standardized objective tests in general mathematics. It is not, however, the purpose or ambition of this paper to criticize or evaluate any of these tests.

One matter of general consideration regarding standardized tests is the fact that they have not been constructed to cover adequately all subjects and subdivisions or units or phases of all subjects; nor do they apply to all local and unique situations of class organization and textbook usage and hence can not be employed as frequently as a test of some sort should be administered. Moreover situations often arise which make it best to give a test or to modify, on brief notice, one previously planned. Certain of the standardized tests are constructed so as to be applied to the subject matter of one particular text book or series of text-books. Others are constructed so as to be used in conjunction with one of a number of recognized textbooks. Then, too, the frequent use of standardized tests, if enough could be found which would seem appropriate to one's own textbook, teaching individualities, local needs and class personnel—for in large schools, many classes in the same subject are graded as to I.Q.—the frequent use of standardized tests creates expense. In fact the frequent use of informal objective tests necessitates the purchase of paper, the use of the typewriter, stencils, the mimeograph machine and stencils of another sort for checking results.

To consider the informal objective test in its forms and uses for algebra, one thinks first of the completion test. It has been and probably will be used more often than any other form. The completion test is moreover the form best suited to the endeavors of the teacher making her first study and use of informal objective testing. During some months this type and the older familiar types should be used exclusively. In general, care and planning are necessary in this type of test so that the response is not suggested by the use of singular or plural forms or the use of the definite or indefinite article or by the use of negatives. It is probably better to make only a gradual and moderate use

of the informal new-type tests, for a careful study of their construction is necessary before satisfactory tests can be constructed.

The alternative or true-false, sometimes called "yes-no" type of test is always open to criticism, due to the element of guessing involved. The formula, $S-R=W$, intended to correct this element leads to dissatisfaction on the part of the pupils. They regard this method of scoring as unfair. There is a small group of pupils of such personality that they almost never guess. Another serious criticism of this form and of the multiple-choice form, as well, is that the answers suggested tend to quicken impressions formerly on the margin of consciousness and thus bring about recognition of the correct responses. The advocates of the exclusive use of the essay form of test maintain that no result of this kind develops in the use of the latter.

The multiple-choice form of objective test merits wide use because of its adaptability to various phases and types of subject matter. It should be used as frequently and perhaps more often than any other form, particularly if the choice is among as many as five suggested responses. However this type should not be used to the exclusion of other types. The correction formula for guessing in the multiple answer test is

$$S = R - \frac{W}{n-1}.$$

The matching test in which a series of twelve to twenty items are matched with the same number taken from an equal number or preferably a larger list, in a confused order, is an interesting type. It however requires more time for the pupil to make selections than the type discussed above. There is no need of correcting the scores by formula.

Incorrect-statement tests, composed of items presented erroneously, are to be made correct by the change, omission or insertion of a word or symbol. They test knowledge rather than pure memory. The element of guessing is small. However this type has little application to algebra. Moreover it is difficult to construct so as to yield highly objective scores.

The analogy test or incomplete proportion can be applied satisfactorily to abstract work in algebra, though its use is limited. For example,———is to———as $9a^2$ is to $27a^6$. This statement admits of a number of correct responses, actually an

infinite number. As a consequence, the objectivity of such a test is not very high.

The continuity or rearrangement test in which items in confused or random order are rearranged in logical sequence applies in algebra probably only to analysis.

At present there seems to be no scheme of objective testing which applies to the solution of concrete or worded problems in algebra unless one awards no credit except for complete and absolutely correct solutions, developed according to directions. Even so, standards of completeness would vary greatly with teachers. The grading would be far from objective.

To consider informal objective testing in geometry, the completion form may be used for many phases and aspects of topics in geometry, plane and solid. The true-false test has its uses, but its adverse criticisms. It might be employed occasionally in the testing of concepts, definitions and for numerical values. The correction of scores to make allowance for guessing should be made. The multiple choice type of test has some uses in geometry, as has the matching test. The latter type is much more difficult to construct for geometrical topics than for algebraic or trigonometric. The incorrect statement test has some applications in geometry. The analogy or incomplete proportion test can be used in geometry as in algebra to the same limited extent and almost exclusively for the same topic. It will lack objectivity to the same extent. The continuity or rearrangement test has somewhat extensive use in ordering confused or random statements into logical sequences, or random reasons for ordered statements into logical sequences, or a confusion of statements and reasons or authorities, all expressed, into an ordered proof. However the scoring of this sort of test is not a very simple matter. Perhaps the elaborate schemes suggested do not warrant the results obtained.

An objective identification test to be applied to figures in geometry is sometimes employed. Excepting in the study of general mathematics or intuitional geometry, the subject matter which can be so tested is of such elementary and trivial character as to render doubtful the merit of the test. The figures must be carefully constructed and reproduced. However it is possible to draw the figures on the blackboard, covering the drawings prior to the entrance of the class. When the pupils have arrived, and have been given directions, they study the

figures from the board and record findings only, in a column on paper. This plan is to some extent a compromise.

Parenthetically it might be noted that a number of the types of objective test may be administered without being multigraphed, particularly the completion, true-false, multiple-choice if there are not more than three choices for one response, and these statements short. Tests consisting of incorrect statements possibly the matching type, if a display has previously been prepared on the board and later is supplemented by dictation may be administered, without being multigraphed. The procedure is never as satisfactory as that developed by the aid of the multigraph. The responses can not be checked as quickly, with a key as they are not so uniform and ordered on the papers, however much care one exercises to endeavor to have them orderly and uniform. There are disadvantages of seeing and hearing from various positions near and remote from the board and the instructor. The time element can not be well regulated. There are always too many repetitions of statements or questions by the instructor, however careful and emphatic one may be in dictating.

To return to the consideration of objective testing in geometry, there are tests of the type to examine the ability to sketch or accurately construct a figure, given worded specifications. There are those which test the ability to draw an inference or conclusion from given data, to separate conclusion from hypothesis, given a theorem, and also tests to develop a converse given a theorem for which no converse had previously been considered. One may test, but perhaps not entirely objectively, a pupil's ability to analyze constructions.

To test the ability to recall additional facts about a figure, when one or more facts are given, leads to responses so many and so varied in extent and importance as to make the scoring of such testing neither impersonal nor objective. To test the ability to select from a collection of available presented facts or items those necessary for a logical sequence and hence the conclusion desired, an ability most fundamental in nature, is a procedure more subjective and more involved in scoring. Finally the scoring of a complete geometric proof, given the theorem alone, an original, is a procedure of the most complex character and almost devoid of abjectivity.

It is possible to test objectively many of the procedures and processes of trigonometry in that trigonometry is more algebraic than geometric in character.

Some studied use of objective testing is desirable in mathematics, from the point of view of the pupil, because this kind of testing permits of variety of form and approach. It measures various abilities. Its variety stimulates interest and industry. Some pupils respond best to one phase of test, others to another, some emphasize speed, others accuracy, some form, others graphic aspects of subjects.

In general there are two purposes in giving tests. They are given for administrative or supervisory appraisal, and they are given for pedagogical diagnosis and subsequent corrective prescription. The determination of existing levels of achievement should be secondary to the improvement of instruction. Testing should justify itself in terms of its contribution to remedial work for young folk. In objective testing, the nature of the responses, made to an educational situation presented, indicates not only whether the pupil has made the appropriate responses, but it also often indicates something of the mental processes involved in determining the response made. It will repay us to endeavor to analyze the mental processes involved whether the response is the one required or not. In this manner our attention can and will be centered upon methods and devices of instruction which will tend to foster correct responses. Tests can be made some of our most helpful instruments for improving instruction if attention is centered upon the analysis and interpretation of results and their determining causes. The character of the appraisal, which develops along with such a study, though almost incidental in importance, is usually adequate to the instructor's needs.

Finally in the matter of testing, it is not a question as to whether the essay or the objective test is the better and then making exclusive use of that type. It is rather a question of determining the occasions and circumstances under which each is more valuable and then of using each accordingly. Each of the types has its peculiar merits and advantages; each has its its limitations, often quite marked, for a particular subject and a unique aspect of that subject. Employ for that subject, and that particular phase of it, the type of test which fulfills the desired ends.

DIAGNOSTIC TEACHING OF CHEMISTRY

By Francis W. Howes
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Data which have been collected from time to time seem to indicate that much of the labor of high school chemistry teachers has been ineffective, and suggest the need for remedial measures which would save time for the student, and also relieve the public of the cost of additional instruction. It is common knowledge that some types of tasks required are more difficult than others, and in these cases a program of remedial teaching should be of pronounced value.

Studies have been made by various writers on the chemistry course, the pupil errors, the methods of teaching, etc., but the writer was unable to find after a careful search of the available literature, any case where a remedial program had been followed with any high school class and the results scientifically treated and recorded. This summary reports a study which was carefully made of four ordinary classes of students, selected at random from the lists submitted for registration. The writer wishes to point out that the records presented there are not the product of conjecture, but of carefully organized and administered measurement.

Beginning classes were used for this work, two serving as experimental classes and two serving as control groups. All four classes were given the Higher Form A of the Otis S.A. Test of Mental Ability. The results when statistically treated, indicated the mean I.Q. of the experimental students as $\pm 105.5 \pm 1.14$ and for the control groups as 104.01 ± 96. The critical ratio, 1.007, indicated that the differences between these two groups was not of statistical significance and therefore no reclassification of the students was necessary. The work of all students is reported in this study save those who were repeating the course.

Certain facts about these students were felt to be desirable, namely—

a. native ability (measured by the Otis test)
b. reading ability (measured by Haggerty Sigma 3)
c. arithmetical ability (measured by Reavis test)
d. home background (questionnaire and personal interviews).

The results of the Otis test have already been indicated. The others follow.

READING

In the study of reading ability, it was found that of the experimental students, only twenty-six, or 37%, made scores of one hundred or better, the norm being 105. Of the control students, twenty-two, or 34%, made scores of one hundred or better. The mean for the experimental group was about 91, while that of the control was approximately 92. This difference did not prove significant. The medians of *both* groups were considerably below the age and grade medians which have been established for this test.

ARITHMETIC

The Reavis-Breslich Diagnostic Test was given to the experimental classes, with the hope of getting two kinds of information, namely—

a. the standing of these pupils compared to the norms, and

b. to find out which types of arithmetical work made the most difficulty, if any number of errors was pronounced enough to make identification possible.

Of the sixty-five students taking the test, only fifteen, or 23%, had total scores equal to the established median (or above it). In both classes the greatest number of errors occurred in addition, fractions, and arithmetical reasoning. The fewest errors occurred in subtraction, division, and the placing of decimal points in multiplication and division. The majority of these students ranked below the median established by giving this test to nearly a thousand high school seniors.

HOME BACKGROUND

In an attempt to get information about the home background of these students, two methods were used—

a. a questionnaire answered by all students, and

b. detailed case studies made of 40 students, of whom 20 seemed to be making good progress and 20 were having trouble in maintaining a good scholarship average.

The results of the questionaire are presented first.

That concrete evidence might be presented regarding the cosmopolitan character of the students studied, they were asked to tell the course they were taking, give the country of their birth and that of each parent, their age, the language spoken at home, their plans for further education, their plans for profession or other occupation when schooling was completed, and the economic standing of their homes.

It was found that six courses were being taken, but eighty-eight per cent of the students were enrolled in General Science and Technical courses. All of these students had been born in the United States, while the fathers were natives of fourteen countries other than United States, and the mothers were natives of thirteen countries other than the United States. The greatest number of both parents were natives of Lithuania and Poland. Nine languages other than English were spoken in the homes of these students, and it was interesting to find that more homes of experimental students used the foreign tongue than was the case with the control students.

The employment situation can best be shown by reproducing the following table:

	Experimental	Control
Fathers working	58	51
Mothers working	16	27
Children working	15	8

A number of families were on the state relief roll at the time this survey was made. The figures on plans for further education, reflected the attitude of many foreign parents, that high school was more than enough schooling for anyone. It is interesting, however, to note that when parents had any ambitions for their children, preparations were in progress for a professional or semi-professional career, never one of a laborer. It seems to the writer that the heterogeneity of the entire group of students used should more than convince anyone that this study was conducted with students *as they are encountered*, and not grouped for special purposes.

Carefully detailed studies were made of 40 students in an effort to find out if extraneous factors had had any great effect on their ability to master chemistry. No definite information of this type was encountered, but the reader might be interested in a few of the more outstanding items:

a. The I.Q. seems to be a very *definite* indicator as to what pupils can accomplish.

b. Parents wished their children to enter professional or semi-professional pursuits.

c. Most parents had no idea, or the wrong idea, as to what further education might be able to accomplish for their children.

d. The use of a home language other than English was found in 73% of the poorer students studied.

e. Reading scores were very low among poorer students.

f. Many items of interest and importance bearing upon the handling of many cases are apparent upon reading the original records.

Much of the material which has been pointed out here would seem to be apparent upon thinking about such groups of students, but in this case we have positive information, obtained by carefully determined procedures.

PROCEDURE

Detailed description of the procedure used can be obtained by reading the thesis, but in this summary we will point out that

a. The control groups were taught in the traditional fashion of text assignment, oral quiz, discussion, laboratory practice and unit tests.

	Unit I	Unit II	Unit III	Unit IV	Unit V	Mid.	VII	Final
Range								
Exp	8–30	4–24	12–26	10–40	0–100	30–46	0–100	14–50
Control	10–30	6–20	14–26	12–38	0–100	26–46	0–100	10–32
Statis. Mean								
Exp.	25.02	16.8	22.54	32.69	85	39	84	32.2
Control	23.00	16.2	21.34	27.12	77	38	66	22.2
Stan. Dev.								
Exp.	4.67	2.58	2.54	4.42	7.2	4.01	7.5	7.56
Control	4.76	2.58	3.32	5.04	9.3	4.26	6.13	6.10
Stan. Error Average								
Exp.	.56	.31	.30	.54	.88	.50	.91	.94
Control	.57	.32	.41	.62	1.15	.55	3.25	.75
Range of 68% cases								
Exp.	20–29	14–19	20–25	26–38				22–40
Control	18–27	13–18	17–24	22–32				16–28
Theta Diff. Means	0.8	0.445	0.5	8.25	1.44	.74	3.37	1.208
Critical Ratio	2.53	1.3	2.55	5.04	8.6	1.75	5.0	8.25
Significant Ratio?	no	no	no	yes	yes	no	yes	yes

b. The experimental procedure was essentially the same except that two days after the assignment had been made, the classes were given one or a series of "worksheets" which consisted of sentences to check, blanks to fill, problems to solve, and also simple explanatory matter covering ambiguous text material. Three days before the close of the unit a preliminary test which was diagnostic in character was given to all pupils and the results tabulated. The purpose of this "pretest" was to facilitate the locating of student difficulties. The purpose was to locate specific difficulties and time was then used in trying to remedy the apparent lacks. "For drill to be effective, it must

be specific." Remedial teaching was all done in class groups, no help being given to individuals except during supervised study periods under the supervision of the writer. It is of course apparent to the reader that the subject matter of any unit determines to a large degree the exact nature of the attack upon it. Some units have much more memory and drill work than others.

The results of this study are tabulated in one collection for ease in comparing the material.

The critical ratio in Unit I and Unit II is large enough that the chances are 99 out of one hundred that the difference was significant, but the policy of this writer has always been not to consider such results significant unless the critical ratio was at least three.

The critical ratio in the final examination was more than twice as large as it needed to be to insure complete reliability. In 20,000 cases of unselected students studied by Dr. Powers, the median was found to be in the interval 26–28. The median of the experimental students was considerably above this mark.

CONCLUSIONS

1. Proof has been submitted and undeniably substantiated, that the series of worksheets is of great benefit.
2. Reading and arithmetical abilities must be somewhere near normal to insure success in chemistry.
3. No evidence was disclosed that would indicate that remedial teaching could be dispensed with at any point during the semester.
4. Undoubtedly, the work could be simplified without losing any of its value.

During the past academic year, the courses offered by the writer have been reconstructed in accordance with the principles set forth in this study, and the results have been gratifying. As more material on this work becomes available, it will be collected and filed as supplementary to the thesis itself.

McGRAW-HILL BOOK COMPANY CELEBRATES

This year marks the 25th anniversary of McGraw-Hill Book Company, Inc. In July 1909 the book department of the Hill Publishing Co. joined with the book department of the McGraw Publishing Co. to form the present book firm. The company truly has a good reason for celebrating, for in 1933 it published 136 new books—seven above the boom year 1929.

THE MIMEOSCOPE IN SCIENCE TEACHING

BY J. MORLEY NUTTING
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Science is the study of concrete things. Few facts are more evident in the science work today. Years ago textbooks were written entirely about theoretical situations and were concerned with the theoretical side of more abstract problems. Today, due in part to the rising prominence of the practical in education, texts deal with things in the realm of life of the pupil and deal with them concretely. This is evidenced, first, by the textbooks of the several sciences and, second, by the trends in teaching procedures in these sciences.

Let us view the separate sciences. Physics is the science of matter and energy. Obviously this is a concrete subject dealing with the very things, the objects and substances which we use in everyday life. And every textbook is replete with pictures and diagrams of those objects which especially illustrate the subject matter of the science. Chemistry is the science of solutions and similar conditions with their interreactions. This is not so obviously concrete but still is concrete enough so that the chemistry text of today deems it wise to picture the subjects to the pupil frequently. Geography is the science of the earth. "Earth writings" are before us every step of the way through life. The city gutter and the country brook, the city bluff and the wilderness peaks demonstrate to the geographer the concreteness of his science. Biology is the science of living organisms, the science of life in so far as life itself may be held up to scientific study. And no biology book and no biologist would attempt to lead his class through their study without the living plant or living animal in class observation. And so our texts today emphasize the concreteness of the science subject matter.

How do teaching methods evidence this problem? In answer to this question we only need to take glances at three different sections of the school business today. In the graduate schools we find experimentation and discussion hinging, not on the problem of abstract vs. concrete science teaching for high schools, not around the lecture vs. the demonstration but rather around the form or method which is to be taken in making science teaching concrete, that is, in presenting it to all the sense channels of the pupil so that the eye-minded (picture-minded) pupil may learn his material dealing with the things around him

just as well as the ear-minded (word-minded) pupil may learn his.

The second picture is the high school class room. We find the furniture arranged "so that all may see the demonstration table." Upon this table we find all sorts of objects displayed, concocted into a crazywork pattern of funny looking "do-dads," "hickies," and "gadgets," according to the particular type of science room we enter. And associated with this room is another room, a laboratory, where the pupil plays with and manipulates other things in this business of making science concrete to him.

And complementary to this is the third picture of the scientific apparatus and supply houses located in strategic towns to sell this apparatus to the schools. The concreteness of subjects in the science department has given rise to a business development running into millions of dollars annually, Thus we see that we have a concrete subject and our methods of handling it in the class room tend to emphasize this property of the science work.

But there is one part of our program which still falls back upon the abstract written page. That is the teacher-made work exercises and tests. The great majority of these today are still lists of questions to be answered out of reference to some other outside source of visually concrete material or by reference to some definitely concrete experience to be recalled by reading an abstract statement about it on the test sheet. Should not such exercises appeal to the different learning patterns of the pupil just as fully as the class room demonstration, laboratory exercise or textbook study? Is it not possible that many students especially in the earlier ages in high school, fail in tests or do not get a solution of a work exercise because their associations do not "click" between the abstract statement and the concrete demonstration?

How can we hurdle this gap in our program? Experience solves many problems and experiment is a way, a concrete way if you please, of gaining experience. The purpose of this article is not to state axioms which this experience has shown to be absolutely true but to pass on a few things that have come out of trying to deal with this problem. Clearly stated the problem has been to construct work exercises and test sheets "at home" which present to the pupil concrete situations which may be objectively handled in teaching and testing.

Three fairly distinct types of exercises are presented, with illustrations, as suggestions. These are exercises or tests built upon the processes of recognition, total recall and of association of many facts and situations in one concrete problem diagram. These three types are fairly distinct in the worded test and need no extensive explanations. The term "exercises or tests" is used because it is often desirable to so word a stencil that it may be used first as a test sheet and later as a review or work sheet. In this way much labor can be saved and a supply of stencils for varied uses accumulated.

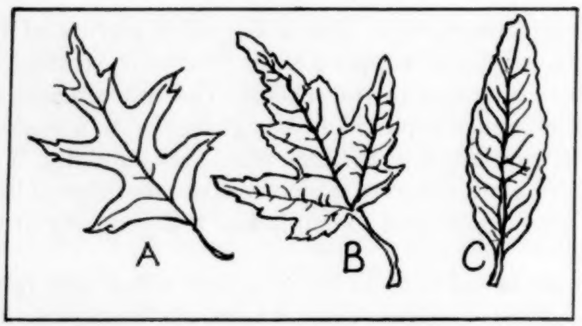

FIG. I. Teacher-Made Recognition Exercise. Leaves.

In the recognition type all the information is supplied in the diagram in such a way that a definite situation or object is presented to the pupil for recognition. Fig. I and Fig. II represent two such situations. The leaves the pupil recognizes by their shapes and veining. The means of disease control are presented by the pictures of commonly known tags or signs used in each control. In each of these exercises the pupil writes down, in space provided, the names of the things recognized. It is the simplest type of illustration test.

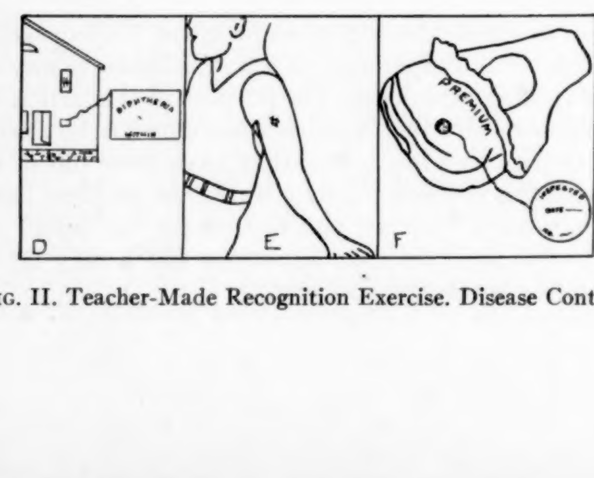

FIG. II. Teacher-Made Recognition Exercise. Disease Control.

A modification of this type of exercise is shown in Fig. III. Here the diagram presents the relations existing between the parts but the pupil has to associate the names of the organs with the organs themselves. It is, of course, a concrete matching ex-

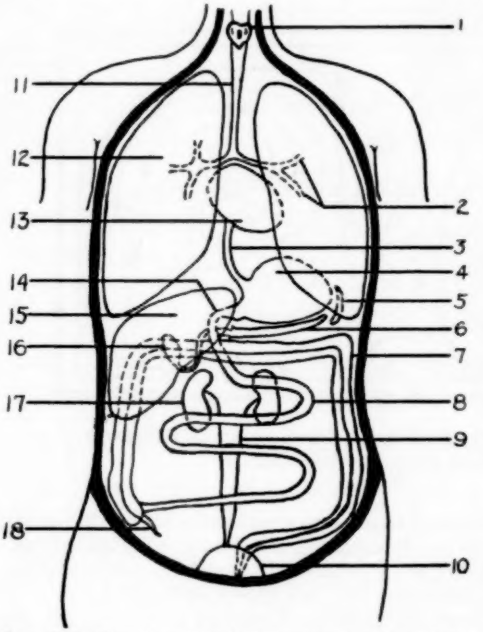

Fig. III. Teacher-Made Illustration for Total Recall or Matching Exercise. Physiology.

WORD LIST

A. Trachea
B. Appendix
C. Liver
D. Kidney
E. Ureter
F. Stomach
G. Pancreas
H. Larynx (voice box)
I. Heart
J. Lungs
K. Spleen
L. Small Intestine
M. Urinary Bladder
N. Gall Bladder
O. Pyloris
P. Large Intestine
Q. Oesophagus
R. Bronchi

ercise. Such an exercise may be varied by adding another part in which the pupil is asked either to associate stated functions with the right organs or to name the functions of designated

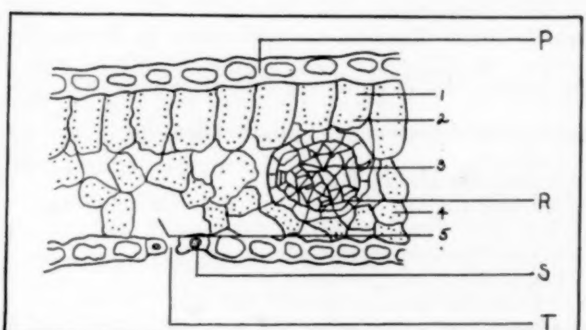

Fig. IV. Teacher-Made Total Recall Exercise. Leaf Structure.

organs. Fig. IV shows how this is done for the leaf structure, as a total recall rather than a matching exercise. The numbered parts are to be named while the functions are to be given for those parts lettered.

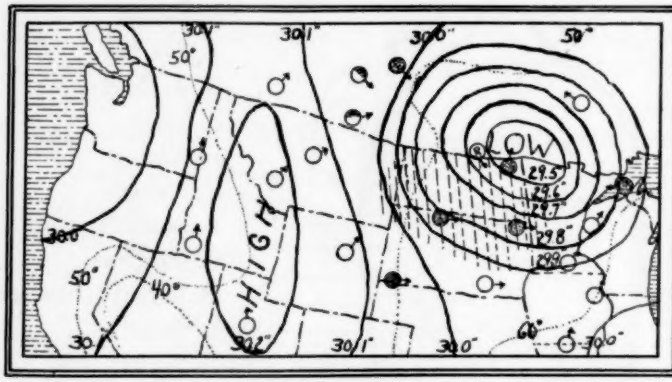

FIG. V. Teacher-Made Illustration for Composite Review or Problem Exercise. Weather.

DIRECTIONS. The diagram above represents a section of a U. S. Weather Map for the Northwestern States. Boundaries are shown in dot-dash lines. Weather data are shown in standard symbols. Answer the questions below by reference to the diagram whereever the data necessary is given.

1. The usual basis for weather is the .... current. 1.......
2. On the map the center of this current is marked as a ....? 2.......
3. On the map the outside of this current is marked as a ....? 3.......
4. The general direction of air drift is ....? 4.......
5. The direction of winds around the "LOW" is ....? 5.......
6. The direction of winds around the "HIGH" is ....? 6.......
7. The shadded circles represent ....? 7.......
8. The specific wind direction for each town is shown by ....? 8.......
9. The instrument used in obtaining data for solid lines is the ....? 9.......
10. The dotted lines represent (a) and are called (b)? 10a....... 10b.......
11. Where is precipitation shown? 11.......
12. After 24 hours the sky will be .... over the present "LOW." 12.......
13. After 24 hours the barometer will be ....? 13.......
14. After 24 hours the wind direction will be ....? 14.......
15. After 24 hours the temperature will be ....? 15.......
16. After 24 hours the precipitation will be ....? 16.......
17. After 24 hours the weather will be controlled by .... in this region? 17.......

Fig. V shows the teacher-made general problem test. In this the teacher makes his diagram to include a large number of related ideas in the interpretation of which the pupil uses the information which he has learned. Teachers can make these diagrams to meet any given set of problems which it is desirable to emphasize.

Careful study and experimentation with this type of work will lead to the adoption of a few simple precautions which are suggested here to aid those starting out in it.

1. It is not desirable to mix types of test indiscriminately in several diagrams on one page. The writer has found that five or six groups of three diagrams of the same type in each makes a usable testing set-up. This makes a fifteen- or thirty-point test and can be made quite comprehensive.

2. Diagrams must be definite, easily understood by the student, concrete, and challenging.

3. Diagrams must not present trick situations.

4. Diagrams must be strictly built according to the type desired. Recognition exercises must contain all essential information in the way of explanatory names, etc. Total recall exercises contain only the relationships expressed in the diagram. Composite problem exercises must present all the factors necessary to the correct solution of the problem.

In presenting this discussion the aim has not been to present new material except as teachers are unfamiliar with the fact that these diagrams may now be made by any teacher in his own home. He need not buy printed material, adapted to other general courses, but he can secure his own mimeoscope at a very moderate cost and, with an amount of practice varying with his own ability, produce good, recognizable reproductions of complex objects like insects, flowers, etc., by freehand drawing, or he can draw diagrams of a mechanical nature with the aid of drawing instruments, or he can trace drawings, illustrations, etc., which he has used in class work from other sources. Thus any teacher, with a small investment, can make his own illustrated tests and work exercises adapted to his own courses of study. That is he can bridge this final gap in making science teaching concrete.

LIVING PLANTS FOR ECOLOGY AND PHYSIOLOGY

By Edwin D. Hull
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GENERAL

The purpose of this paper is to discuss those living plants which are most useful in the study of ecology and physiology. No attempt is made at a complete survery, but only to show what is little or not at all known, or in the case of familiar plants those about which new data can be given.

Few plants (these are indicated in the paper) will withstand the severe conditions of the school room. The others must be grown under glass, for which a greenhouse is best, but if this is not available then a contrivance known as the Wardian Case is a fair substitute. This is simply a box, of a size to be determined by the needs of the teacher, with sides and top of glass, and placed preferably close to a south window to afford a maximum of light. This can be built by a local carpenter for a reasonable price.

ROOTS

Adventitious Roots: An excellent plant to show this type of root is the Water Pennywort (Hydrocotyle umbellata), found in nature mostly on the coastal plain from Massachusetts to Florida and Texas, but also occurring inland in Michigan, Indiana, and Minnesota. It is to be looked for along the margins of ponds and in swamps, in habitats that are little or not at all shaded. Given a wet soil and abundant sunlight the plant grows very well in cultivation, sending out creeping stems which at each node send out a single leaf, and many roots. Other species of *Hydrocotyle* may be tried.

Roots as Aerating Organs: Comparable in function to the "knees" of the Bald Cypress are spongy, thick and white structures which arise from the stems of the aquatic Primrose Creepers (Jussiaea). These are true roots, growing upward and serving as aerating organs. Perhaps the best of these is *Jussiaea repens*, obtainable from dealers in aquatics, and readily cultivated in shallow water.

Water Roots and Root Pockets: Best of plants to show this is the Water Lettuce (*Pistia Stratiotes*), native in the southern United States, obtainable from many dealers in aquatics, and

easily grown in a vessel with about a foot of water and a bottom of rich soil. The roots are produced in great abundance, and show very conspicuously the curious root pocket of aquatics.

LEAVES

Photosynthesis in Green Tissue Only: The best for this purpose seems to be a well known foliage plant, the Silver Leaf Geranium, a variety of the common Fish Geranium (*Pelargonium hortorum*). The leaf has a white margin, varying in width in different leaves, and destitute of chlorophyll. The plant will do best in a rather cool atmosphere and considerable sunshine.

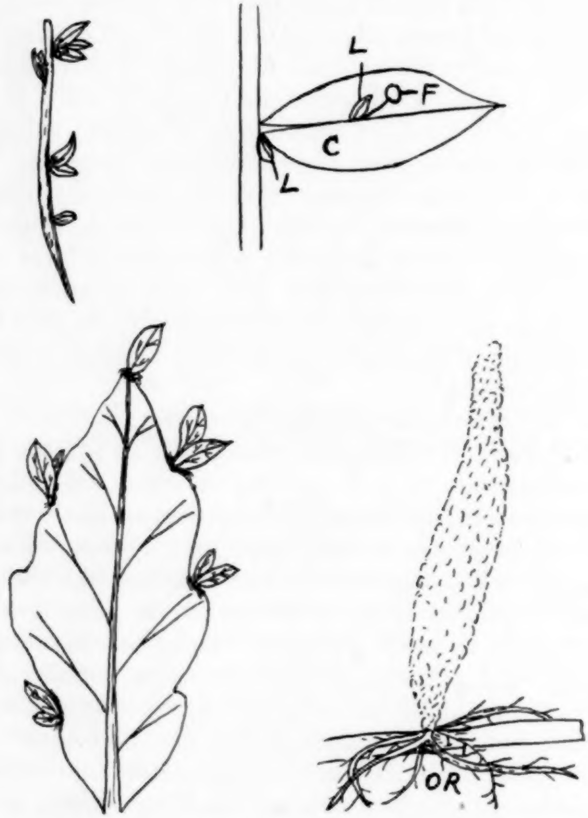
Release of Oxygen during Photosynthesis: The plant commonly used for this experiment is the Water Weed (*Elodea canadensis*), common in slow streams and ponds, and in a giant form, usually called *Anacharis*, sold by dealers. It is only necessary to point out that much more satisfaction will be had if the wild form is used, as the giant *Anacharis* has, in some cases at least, given no satisfaction at all.

Leaves as Reproductive Organs: The classic plant to show this is the Life Plant (*Bryophyllum pinnatum*). To get the best results it is necessary to place the leaf on moist soil and keep in a humid atmosphere. If kept dry only roots are likely to appear. Best of all, however, is the Water Fern (*Ceratopteris thalictroides*), a floating plant with a native range like that of the Water Lettuce, and easily grown under the same conditions, and offered by dealers in aquatics. Even small fronds produce young plants in abundance over the upper surface. Another very good plant is the Hen-and-Chickens (*Echeveria secunda*), a common bedding plant, much like the well known House Leek, but differing in its bluish foliage. Leaves should be carefully broken off, and then treated like *Bryophyllum*, when new plants should soon appear at the broken ends.

STEMS

Photosynthesis by Stems: (*a*) *Ordinary Stems:* This topic is best treated in three divisions. In the first the leaves are scale-like and do not function. A very good plant in this respect is the Prickly Pear Cactus (*Opuntia*), easily grown from seed, which should germinate within a week if planted in a sandy, warm and moist soil, or it can be secured in a more advanced stage. This plant should live in the school room without special treatment. *Opuntia* has many species, most of which are

in the southwest, but one, *O. vulgaris*, is common in the east, and another, *O. Rafinesquii*, is common in sandy or gravelly soil in the central states. In the second category are leaves reduced in size though still functional, but appearing late and falling early, the stems being bright green and doing most of



Upper, left to right. Hypocotyl of Flax Seedling with adventitious buds; Diagram of Ruscus aculeatus (L-leaves, C-cladophyll, F-flower).
Lower, left to right. Leaf of Water Fern (Ceratopteris) with young plants; Aerating Root of Jussiaea repens (OR-ordinary roots).

the work. Here belongs the Scotch Broom (*Cytisus scoparius*), a European plant naturalized in sandy barrens near the Atlantic coast in Nova Scotia, and from Massachusetts southward. Seeds or plants can be obtained. In the third category the leaves are large, but yellowish green, and deficient in chlorophyll, in contrast to the stems which are a brilliant green. Here are cacti

belonging to the genus *Pereskia,* the only cactus group whose leaves are not reduced to scales.

(*b*) *Cladophylls:* These are stems which superficially resemble leaves. The plant most easily obtainable is a species of ornamental Asparagus (*Asparagus Sprengeri*), which is possibly able to endure school room conditions. A better form of Asparagus, having broader and more leaf-like cladophylls is the florists' Smilax (*A. asparagoides*). Best of all plants in this connection are species of Butcher's Broom (*Ruscus*), in which not only the cladophylls are strikingly leaf-like, but flowers appear in the center of them, arising in the axil of a scale-like leaf. The most available species is *Ruscus aculeatus,* often planted in the southern states, the sprays of which, dyed red, are commonly seen in Christmas decorations.

Tubers: An admirable plant to show tubers, and one easily grown in the school room, is the Tuberous Sword Fern (*Nephrolepis cordifolia; N. tuberosa*), closely related to the common Boston Fern. Tubers are produced in great abundance on underground stems, and will send up new plants readily if removed from the parent, and placed horizontally just underneath the soil.

Adventitious Buds: To show these flax seedlings are the best, either the common flax which furnishes linen (*Linum usitatissimum*), seeds of which can be had from the drug store, or the Flowering Flax (*L. grandiflorum*), to be obtained from seedsmen. The latter, perhaps, is somewhat better. Seedlings should be allowed to stand for a few days until perfectly erect and somewhat rigid then the plant should be severed just below the cotyledons, leaving only the hypocotyl along which buds should develop in abundance. Many (20 or more) seeds should be planted, as some of the seedlings will probably die after the cut has been made.

A NEW DICTIONARY

A SUGGESTED COURSE OF STUDY FOR JUNIOR HIGH SCHOOL MATHEMATICS

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In constructing a course of study in any subject for the junior high school it is necessary to constantly bear in mind certain guiding principles regarding the needs of the individual and of society, and the function of the junior high school in meeting these needs. The underlying philosophy of the junior high school is incorporated in the following four fundamental principles: (1) articulation; (2) exploration, revelation, and guidance; (3) interpretation of environment; and (4) motivation.[1] The selection and organization of curriculum content must be in the light of these principles and any particular program must be tested in terms of its capacity to successfully function in the educational emancipation of the individual and in the social integration of the aggregate of individuals.

In the late summer of 1916, under the auspices of the Mathematical Association of America, there was organized the National Committee on Mathematical Requirements. The purpose of this organization was to give unified aid to the movement for reform in the teaching of mathematics. This committee made an attempt to establish contacts with all organizations of teachers and others interested in its problems. Reports of various phases of the problem were submitted to these several organizations and their comments and criticisms invited. Thus the committee felt that the recommendations of their final report, published in 1923, had the approval of the great majority of the progressive teachers of mathematics throughout the country. This report set forth aims and objectives for instruction in secondary mathematics and gave detailed discussion of the mathematical content for grades seven to nine, and ten to twelve.[2]

In 1925 Schorling published his "A Tentative List of Objectives

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[1] J. M. Glass, "Tested and Accepted Philosophy of the Junior High School Movement," *The Junior-Senior High School Clearing House*, Vol. 7 (March) 1933, pp. 329–339.

[2] *The Reorganization of Mathematics in Secondary Education*, Report of the National Committee on Mathematical Requirements, The Mathematical Association of America, Inc., 1923, pp. 3–42.

in the Teaching of Junior High School Mathematics" in which he broke away from the traditional classifications of aims and objectives by grouping them under attitudes, concepts, information, and skills or abilities.[3] This list was made up of 477 statements or facts which he termed "objectives," elements," or "items." They were derived from twenty-nine objective studies, seven junior high school mathematical series, two studies determining practice from courses of study, and the above mentioned report of the National Committee on Mathematical Requirements. This list was then submitted to "a competent jury" composed of five leaders in the teaching of mathematics and five general educators.

In 1931 Coates found that seventy-nine teachers, supervisors, and authorities in the teaching of mathematics recommended as the most effective technique for setting up objectives a combination of the three following procedures:

(1) Acceptance of the objectives recommended by authorities in the teaching of mathematics, viz., the report of the National Committee on Mathematical Requirements.

(2) A careful survey of the published works of those investigators in the field of education who have studied the problem and their conclusions and recommendations followed, viz., R. Schorling "A Tentative List of Objectives in the Teaching of Mathematics."

(3) The use of courses of study of representative school systems as a base for the formulation of the list of aims and objectives.[4]

With this recommendation in mind a definite program was outlined by means of which the mathematical topics to be taught in the junior high school, their place in the organization of the course, and their relative importance were to be determined. This program resolves itself into four essential parts: (1) an analysis of the units found in eight series of modern junior high school texts, (2) an analysis of units found in fourteen recently revised courses of study gathered from all sections of the United States, (3) the Report of the National Committee on Mathematical Requirements, and (4) Schorling's "A Tentative List of Objectives in the Teaching of Mathematics."

In the textbook analysis, each book was divided into two parts, each part representing approximately one semester's work. This part of the study, supported by the results of a similar detailed analysis of nine series in junior high school

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[3] Raleigh Schorling, *A Tentative List of Objectives in the Teaching of Junior High School Mathematics*, George Wahr, Ann Arbor, Michigan, 1925.

[4] J. D. Coates, "A List of Objectives in Teaching Senior High School Mathematics," Unpublished Master of Arts Thesis, George Peabody College for Teachers, 1931, pp. 6–7.

mathematics,[5] revealed a course of study quite similar to *Plan A* suggested by the National Committee.[6] It is as follows:

7-B

(1) Review of Fundamentals, (2) Percentage, (3) Graphs, (4) Linear Measure, (5) Measuring and Drawing Angles, (6) Geometric Construction.

7-A

(1) Geometric Construction, (2) Areas, (3) The Circle, (4) Volumes, (5) Applications of Percentages, (6) Business Forms.

8-B

(1) Review of Fundamentals, (2) Practical Mathematics, (3) Right Triangles, (4) Volumes, (5) Expressing Relation between Numbers, (6) Algebraic Equations, (7) Practical Measurements.

8-A

(1) Banking and Investment, (2) Insurance and Taxes, (3) Positive and Negative Numbers, (4) Linear Equations, (5) Problems solved by Formulas.

9-B

(1) Expressing Relation between Numbers, (2) Positive and Negative Numbers, (3) Fundamental Operations, (4) Linear Equations, (5) Special Products, (6) Factoring, (7) Continued Work in Equations, (8) Fractions.

9-A

(1) Fractional Equations, (2) Equations in Two Unknowns, (3) Roots and Powers, (4) Quadratic Equations, (5) Variation and Proportion, (6) Trigonometric Ratios, (7) Demonstrative Geometry.

An investigation of the courses of study revealed that all fourteen conformed to the recommendation of the National Committee in requiring mathematics throughout the three years of the junior high school period. The procedure in the analysis of these courses of study was the same as in the analysis of the texts. Six courses contained time limits, consequently, in addition to the topical analysis, tabulation was also made to determine the average time allotment for each unit. The choice and arrangement of subject as determined by the prevailing tendency found in the analysis of the fourteen courses of study is:

7-B

(1) Fundamental Processes, (2) Percentage, (3) Graphs, (4) Linear Measurements, (5) Measuring and Drawing Angles, (6) Geometric Constructions, (7) Areas, (8) Business Forms.

7-A

(1) Geometric Constructions, (2) Areas, (3) Volumes, (4) Applications of Percentage, (5) Business Forms, (6) Equations.

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[5] Josephine Stone, "A Quantitative Analysis of Junior High School Mathematics Texts," Unpublished Master of Arts Thesis, George Peabody College for Teachers, 1926.

[6] *The Reorganization of Mathematics in Secondary Education, loc. cit.*

8-B

(1) Practical Mathematics, (2) Right Triangles, (3) Volumes, (4) Graphs, (5) Investments, (6) Banking, (7) Equations.

8-A

(1) Investments, (2) Insurance and Taxes, (3) Positive and Negative Numbers, (4) Linear Equations, (5) Fundamental Operations.

9-B

(1) Expressing Relations between Numbers, (2) Linear Equations, (3) Positive and Negative Numbers, (4) Fundamental Operations, (5) Special Products, (6) Factoring, (7) Fractions.

9-A

(1) Fractional Equations, (2) Equations in Two Unknowns, (3) Powers and Roots, (4) Quadratic Equations, (5) Ratio, Proportion, Variation, (6) Trigonometric Ratios, (7) Demonstrative Geometry.

Using the results of these two analyses and checking them against the objectives set up by Schorling[7] and those recommended by the National Committee on Mathematical Requirements[8] a course of study for junior high school mathematics was constructed. In formulating this mathematical program certain additional fundamental criteria have been followed. The evolution of a social order quite naturally creates new situations and consequently any educational program based entirely on practice might fail to make fundamental provisions for the new order of things. This status of affairs makes for the elimination of obsolete subject matter and the inclusion of new relevant material. The following criteria served as guiding principles in the ultimate selection of material:[9]

(1) Is the material of practical use in life?
(2) Does the material coincide with the practices of the business world?
(3) Can the material be understood by the children and used, therefore, for a broadening experience?
(4) Are there certain phases of the topic which should be taught for informational value as opposed to skill value?
(5) Does the topic contribute in any way to the development of general quantitative concepts?
(6) Is the material desirable as a foundation for later mathematical work?
(7) Will the topic be of interest to superior pupils even if of little or no value to others?
(8) Does the daily work in (*mathematics*) contribute its full share of situations calculated to build habits of self-reliance and independence in the pupil?

Another very important feature in the organization of a course of study is the planning of a good beginning. There are

[7] Raleigh Schloring, *op. cit.* pp. 99–116.
[8] *Reorganization of Mathematics in Secondary Education*, *loc. cit.*
[9] R. S. West, Charles E. Greene, W. A. Brownell, "*The Arithmetic Curriculum*," Twenty-ninth Yearbook of the National Society for the Study of Education, 1930, pp. 82–83.

junior high school courses now in operation which begin with arithmetic, algebra, or geometry. Justifying arguments may be presented for each, however, it seems that there are certain advantages in the use of arithmetic which far outweigh the disadvantages. One argument presented by some against the use of arithmetic as a means of introducing the work in junior high school mathematics is that, after the years spent in the arithmetic of the elementary and intermediate grades, the pupil welcomes a change. On the other hand, the student just entering the junior high school is confronted with so much that is entirely new to him that the familiarity of subject matter should serve as a cynosure to help him keep his bearings. After a brief review of arithmetic, intuitive geometry may be approached through the concept of the graph and linear measurement, thus making a natural introduction to the new and unexplored.

With the above considerations in mind the suggested course of study is now presented.[10] The column headings should be read T = time in weeks, B = books used as texts, C = course of study, S = Schorling, NC = National Committee.

Units of Subject Matter	T	B	C	S	NC
7-B					
1. Review of Fundamentals Intensive drill with continued practice averaging ten minutes daily on reading and writing numbers up to billion and the Roman numerals. History of the number system; fundamental operations with integral numbers of four or five digits, common and decimal fractions. Short cuts in multiplication and division. Checking results.	2	7	14	b	x
2. Percentage Language and meaning of percentage. Fundamental problems with simple applications. Conversion to decimals and vice versa. Simple interest.	4	6	10	b	x
3. Graphs Construction and interpretation of bar and line graphs, and graphs of formulae.	2	6	9	b	x
4. Linear Measurements Measuring distance with ruler and compasses. Approximate measures and rounded numbers. History and systems of	2	6	4	b	x

[10] The table is read as follows: Review of Fundamentals to have 2 weeks time alloted to it; it was found as a unit in 7 books, 14 courses of study, in Schorling's basic list of objectives and is recommended by the National Committee. Schorling had a basic and a subsidiary list, an *s* in the column headed by Schorling's name means that the particular unit is to be found in the subsidiary list.

Units of Subject Matter	T	B	C	S	NC
measure. Scale drawing and use of coordinate paper.					
5. Measurement and Drawing of Angles Concept of and methods of lettering and reading angles. Classification and construction of angles. Use of protractor.	2	4	8	b	x
6. Geometric Construction Beginnings of geometry, geometrical forms in art, architecture, and nature. Recognition of most important plane figures. Use of ruler and compasses in construction.	4	2	8	b	x
7. Margin of time in first semester of 7th grade	2				
7-A					
1. Drill on Fundamentals (Daily drill from 5 to 10 minutes)	D*	8	14		
2. Geometric Construction History of geometry, study of symmetry and similarity in geometry of nature and art. Bisecting line and angle, construction of simple triangles. Construction of equal angles and congruent triangles.	2	5	6	b	x
3. Areas Meaning and use of square measure involving simple problems. Development of area formulae for triangle, rectangle, square, parallelogram, trapezoid. Scale drawing.	3	8	7	b	x
4. The Circle Meaning of terms. Determining value of π by measurement. Construction and interpretation of circle graphs. Area.	1	5	4	b	x
5. Measurement of Solids Volumes of simple solids with applications.	2	7	7	b	x
6. Applications of Percentage Review of fundamentals; profit and loss, discount, commission and interest.	6	6	9	b	x
7. Business Forms Study of business forms used in daily life.	3	4	8	b	x
8. Margin of time in second semester of 7th grade	1				
8-B					
1. Drill on Fundamentals (As in 7-A)	D*	7	9		
2. Practical Mathematics Problem solving with estimation and checking of results. Percentages, discount, commission and budgets.	3	5			
3. Square root in connection with right triangle. The Pythagorean theorem. Use of tables of squares.	2	5	6	b	x
4. Volumes (as in 7-A)	1	5	6	b	x

* Daily.

Units of Subject Matter	T	B	C	S	NC
5. Functional dependence Review of work in graphs; frequency graphs, ratio and proportion.	3	4	9	b	x
6. Statistics Introduction through statistical graphs, interpretation of frequency distribution and statistical tables, calculation of averages.	2	1	5	b	x
7. Algebraic equations Meaning and use of symbols, formulae as equations, simple equations.	4	6	7	b	x
8. Margin of time in first semester of 8th grade	3				
8-A					
1. Banking Function of banks, nature of saving and checking accounts, use and form of checks, interest and discount, promissory notes, foreign money.	3	7	5	b	x
2. Investments Stocks, bonds, mortgages, real estate, building and loan, savings accounts.	4	7	5	b	x
3. Insurance Meaning and nature, types, terms and rate.	1	6	9	b	x
4. Taxes Meaning and necessity of taxes, sources of revenue.	2	6	9	b	x
5. Algebraic symbolism Use of symbols and nature of formulae.	2	4	9	b	x
6. Positive and negative numbers Use of signed numbers in connection with temperature, latitude and longitude, A.D. and B.C., graphic representation, fundamental operations.	2	3	9	b	x
7. Linear equations in one unknown Use of axioms, transposition as a short cut, checking, simple verbal problems.	2	3	6	b	x
8. Margin of time in second semester of 8th grade	2				
9-B					
1. Functional dependence Formula, the graph, and functional tables	2	7	6	b	x
2. Linear equations (Extension of 8-A)	2	7	8	b	x
3. Positive and negative numbers (Extension of 8-A)	2	7	6	b	x
4. Fundamental operations in algebraic situations. Also removal of not more than two nests of parentheses. Checking by numerical substitution.	3	7	9	b	x
5. Special Products $(a+b)^2$, $(a-b)^2$ $(a+b)$ $(a-b)$, $(a+x)$ $(a-y)$. Simple equations involving special products.	2	5	10	b	x

Units of Subject Matter	T	B	C	S	NC
6. Factoring Removing monomial factor, a perfect trinomial square, difference of two squares, trinomial product of two binomials.	3	7	9	b	x
7. Fractions Reduction to lowest terms, multiplication and division, addition and subtraction. Simple complex fraction.	3	6	9	b	x
8. Margin of time in first semester of 9th grade	1				
9-A					
1. Fractional Equations Clearing of fractions. Problems involving fractional equations.	2	5	6	b	x
2. Linear Equations in Two Unknowns Solution by addition and subtraction, by substitution, by graphs. Verbal problems.	2	5	6	b	x
3. Exponents Meaning and use. Zero, negative, and fractional. Fundamental operations involving both numerical and literal exponents.	1	7	8	b	x
4. Radicals Methods of rationalization and reduction. Fundamental operations.	2	7	8	b	x
5. Quadratic Equations Types of quadratics. Solving by completing square, factoring, formula, and graphs. Verbal problems.	3	7	7	s	
6. Ratio, Proportion, and Variation Functional dependence.	1	6	7	b	x
7. Numerical Trigonometry Sine, cosine, and tangent. Solution of right triangle by natural functions. Verbal problems.	3	7	7	b	x
8. Demonstrative Geometry Need of proof. Congruence theorems, sum of angles of triangle, Pythagorean theorem, parallel lines, simple constructions.	3	3	5	b	x
9. Margin of time in second semester of 9th grade.	1				

There are some intrinsic features of this course of study which are worthy of special note. Adequate provision has been made for maintenance of and remedial work in the fundamental skills of arithmetic. Studies made by Bridges[11] and Schorling[12] reveal that there is a striking need for the reteaching of the funda-

[11] W. A. Bridges, "Mathematical Ability of Pupils Entering the Junior High School," Unpublished Master of Arts Thesis, George Peabody College for Teachers, 1931.

[12] Raleigh Schorling, "The Need for Being Definite with Respect to Achievement Standards," *The Mathematics Teacher*, Vol. XXIV, 1931.

mental processes in the junior high school. The objective of continued practice should be to attain a high degree of accuracy and speed in the four fundamental operations.

The value of checking is emphasized throughout the course of study. In connection with the checking of individual problems the administration of the above course of study should provide for frequent tests as a check on the mastery of the material studied. The unit organization implies such a testing program.

Provisions made for lessons in appreciation and history make possible a further development of the scope and power of mathematics. Such provisions along with optional material and supplementary exercises afford ample opportunities for taking care of individual differences. Furthermore, the effort is made to relieve mathematics of the stigma of a mere "tool subject" and to elevate it above the level of manipulative mechanics and to place it in its proper setting as a fundamental mode of thinking.

ULTRAVIOLET DEATH EFFECTS DIFFER ACCORDING TO WAVELENGTHS

Ultraviolet rays kill plants in shorter or longer time, and with greater or less expenditure of energy, according to the particular wavelengths used. Researches bearing on this point have been conducted at the Smithsonian Institution by Dr. Florence E. Meier, and are discussed in a new Smithsonian publication just off the press.

Dr. Meier's method was to coat glass plates with a film of living one-celled algae, microscopic water-plants, and then to project on it a band of ultraviolet radiation which had been split up into its component wavelengths by means of a prism, just as white light can be split into a spectrum or artificial rainbow.

Studying the killing effects of eight different wavelengths in the ultraviolet, Dr. Meier discovered that each had its own specific "radiotoxic spectral sensitivity"; that is, its minimum quantity that would sooner or later result in death. Each wavelength also had a specific "radiotoxic virulence"; that is, the measure of time required to produce the killing effect.

The two qualities do not necessarily go together. Some of the wavelengths would kill the algae with a very small dose, but required a long time to do it. Other wavelengths had to be applied in larger doses, but killed more quickly when the necessary quantity was reached.

To illustrate her point, Dr. Meier used the analogy of poison-effects on human beings. Radium in watch-face paint will kill in extremely small doses, but may take years to finish off its victim. A considerably larger quantity of rattle-snake venom is required to kill, but if that quantity is used, death is a matter of a few hours at most.

The wavelengths of ultraviolet radiation studied by Dr. Meier ranged between 3022 and 2536 Angstrom units. An Angstrom unit is a ten-millionth of a millimeter, and a millimeter is approximately a twenty-fifth of an inch.—*Science Service.*

MORE NATURE TRAILS
A Project in Out-Door Biology

By Franklin R. Meyers
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Though we admit the great value of the labratory in high school science teaching, still it seems that in some of the biology students who come to me there is a sub-surface feeling of unnaturalness; as if they had said, "We should have liked to learn these facts you are teaching us out-of-doors." Needless to say, it is impossible to teach the entire subject free of the necessary tools of laboratory technique within four walls, but our plea is that where this can be done, we exert ourselves to take biology out where probably it first was taught—in the fields and woods.

The building of nature trails is one such possibility of "airing" biology.

At Bernards High School in 1929 such a project was initiated with the construction of over a mile of paths through a neighboring school woodland which fortunately was close at hand. This area, part of a larger acreage given to the school district, was undeveloped up to that time. With the cooperation of the Manual Arts class brush was cleared, wet places made passable, bridges erected over small streams, an entrance built, and plants and other objects labeled with linen tags. Later the names were removed and a contest held in June (which has been held each succeeding spring) with prizes awarded to those naming correctly the greatest number of plants. Each year brings with it new ideas for development and use of the trail. Like many other constructive projects its growth is never complete.

The organization of the project has been modified as varying numbers of students participated, as class schedules changed, and for other like reasons. In its present form it has seemed most satisfactory to have an organization where each one is engaged in a specific part of the work, knowing exactly his task in the project's completion. Accordingly, each biology class elected a chairman or president, vice-chairman and historian, and selected four committees as follows, each with a chairman:

1. Clearing Trail
2. New Plants
3. Labels
4. Publicity

The rotation of officers and committees often is desirable to allow others to receive the training these offices afford. The season, however, is not long so that this together with the fact that each group did diversified work when certain days were given over to the plans of one committee, caused us to retain the general officers, rotating solely the committee chairmen.

Those expressing preference for a certain type of activity were enrolled under that committee. Every member of the general officers thus appeared in some division. The definite duties of each office and committee were determined by discussion, the historian recording the decisions.

All the following suggestions were not of course initiated by the students, but under the enthusiasm which was bound to arise, a suprising number of good ideas and plans were presented.

Those belonging to "Clearing Trail" had the duties of: (1) removing trail obstructions, (2) pruning dead wood along trail, (3) making path walkable, (4) building up damp sections, (5) constructing plank bridges, and (6) exploring for and blazing new trails.

If one were a member of "New Plants" he was to: (1) arrange a campaign week for all to bring new plants, (2) select suitable locations for different species and (3) establish different plant societies, i. e., ferneries and moss gardens.

The "Label" Committee (1) reviewed the previous years' tags, setting aside those requiring re-writing, (2) noted plants of the trail or new plants needing labels, (3) helped in assigning the writing of labels to especially competent ones, (4) directed their printing and varnishing and (5) took charge of their proper placement on the trail.

"Publicity" (1) made the proper announcements in Assembly, (2) prepared an article for the school and local papers and (3) edited a "Nature Trail Bulletin."

When the proper day arrived for a great effort in trail cleaning, label writing, or other activity, the group as a whole became a large committee working with the special committee. This necessity perhaps aided all to see better the project as a whole rather than merely its several parts.

In order to keep the organization plan well before the students, a typewritten list of committees with their duties was placed on a movable bulletin board which was kept at hand for general nature trail meetings.

In preparation of labels, one plant or more was assigned to a student who was asked to look up all relative information concerning the species: its correct name, characteristics, past or modern uses and range and to gather any historic or legendary matter which might be of interest. Then the points which a good well written label should possess were discussed.

It was decided that a label should be:

(1) Not too long—not over fifteen or twenty words.
(2) Interesting—should tell most striking, interesting, or useful fact.
(3) Grammatically correct.
(4) Correct in spelling.
(5) Free of technical language unless explained.
(6) Conversational in tone—not bookish.

The outline of a linen tag was drawn twice, and the student asked to prepare two different labels of the same species, striving to maintain the principles of good label-writing agreed upon. Often this was difficult work for many and required several efforts before a passable label was produced. If the result was satisfactory it was accepted or rejected by the committee as the case happened to be.

The writing of the label then followed. Dennison's heaviest linen tags number 8L were used. It has been found that this type is most satisfactory because it requires less time in writing while if spoiled in preparation or later lost or removed from position, this is not serious from the standpoint of cost. Lettering of the labels was done with India ink using a number 3 ball point drawlet pen. The labels were then varnished to withstand the weather. Tree drippings may easily be removed occasionally by washing if labels are prepared in this manner.

The following are a few examples of what seem to be reasonably appropriate labels:

WILD BLACK CHERRY

Horizontal air-slits in the bark like the Birches.

SKUNK CABBAGE

Large green leaves are making and storing food for an early start next summer.

EBONY SPLEENWORT

The smallest fern of our neighborhood. The frond has a black stem.

HAIRCAP MOSS

A hairy "cap" over the spore case.

FIVE-FINGER

See the five leaflets making up the leaf. Don't confuse it with the strawberry which has three leaflets.

RUE ANEMONE

The leaf resembles the print of a bird's foot.

EDIBLE

If lost in the woods, the small nut-like root of the Hog Peanut may be eaten.

A CHIPMUNK'S DINING TABLE

These nuts have been skillfully opened for the kernel inside.

A few important facts and principles lending themselves to concrete illustrations on a nature trail are:

The main divisions of the plant kingdom.
The correct method of pruning a limb.
Certain plant associations.
Methods of plant reproduction.
Life stages of insects.
Insect damage.
Insect homes—gall makers.
Ravages of plant diseases, i.e., the chestnut blight.
Seed dispersal.
Leaf forms and external structure.
Leaf arrangement.
Twig characteristics.
Tree forms.
Healing of a tree wound.
Soil types.

In addition, a nature trail is an ideal place for bird and animal study, the study of spring plants, the trees of the community and in many other ways appropriate to biology.

As outlined above, our nature trail organization naturally has not always run smoothly. In spite of care, work sometimes was poorly done. This we suppose is true of all teaching endeavor. Occasionally the humorous appeared as in the case of the boy who, though the trail was to be informally arranged as any woods, planted violets row upon row along the path like a new crop of spring cabbages. The enthusiasm shown however in such out-of-door biology leads us to believe the lesson of sympathy and understanding of wild life is being unfolded. Those who have advanced in school often have returned to us with plants collected for the nature trail and with helpful ideas for its betterment. Through the activities of the Student Organization, a real respect for the constructive efforts put into the project is being developed and includes real care and consideration for school property involved.

A nature trail project also may receive encouragement and help from community organizations. Such is the case in our town where the Bernardsville Garden Club has actively inter-

ested itself in the planting of native trees and shrubs through parts of the woodland.

"More nature trails" should be a forward looking plan of those biology departments to whom such a project is a possibility. Whether it is in a city park, in a patch of private woods made available by some interested citizen, or is just a path about the grounds or athletic field, the values we believe inhere in nature trails will thus be placed within the reach of many.

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ATOMS IN ACTION
No. 1 Exploding Atoms

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Ancient alchemists were following a will-o'-the-wisp when they were trying to convert base metals into gold. When chemistry, founded on discoveries made in the laboratory, took the place of alchemy it was slowly and laboriously discovered that while many chemical substances called compounds could be changed into other compounds, there were a few things which defied change. And these the alchemist called atoms, because, as the word literally means, they could not be cut in two. Whenever a substance, like water, could, by any known means, be separated into two or more parts it was called a compound, and the irreducible parts, hydrogen and oxygen were called elements.

One by one new elements were discovered until now there are 92 in the list, or 93 if the newly found negative particle called a neutron should, as some claim, be classed as an element. But even before the discovery of the last of these elements it was found that for some of them the word atom in its literal Greek sense did not apply so well as had been supposed. It was found that although neither the chemist nor the alchemist could di-

vide the atoms of the elements and make new ones the atoms themselves were slowly dividing and new elements were being formed.

This transmutation as the alchemists would have called it, had they known of it, does not seem to apply to all elements. Only the heavier atoms show any very noticeable tendency to separate and form lighter ones. Of these radium, fifth from the heaviest atom, number 88 counting from the lightest up, is the best known and most remarkable of the group.

The elements whose atoms change into atoms of other elements are spoken of as the radioactive substances. The suffix active is well chosen, for the atoms do not simply fall to pieces, they explode, like the popping of corn. Pent-up energy seems, for some unknown reason, to be suddenly released, a part of the atom is torn loose and thrown out with violence, and a little bundle of waves is radiated away, having a wave length far shorter than that of light, and a penetrating power greater than that of the X-ray.

No one knows why the radioactive atoms explode, nor why they do not all explode at once, or at least at some different rate from the rate at which their disruption does take place. Every one of them has some special rate of disintegration of the atoms of which it is composed. For instance in radium one atom in every 2500 explodes each year, and this rate cannot be hastened or retarded by anything man can do to the radium. Out of a milligram of radium (which contains approximately 2,700,000-000,000,000,000 atoms), about 37,000,000 atoms will change into something else each second. Of course, as the quantity of radium left becomes smaller the actual number of atoms disintegrating in a given time becomes smaller because it is a certain fraction of those remaining that explodes each second. Although millions of atoms change in a second the total number of atoms is so large that nearly 1600 years elapse before half of the radium is gone.

Uranium, another of the radioactive elements, is much more stable than radium. Its atoms explode only about one three-millionths as frequently. That is, in a year only one atom explodes out of some 75 million atoms of the uranium. To shrink to half its volume uranium requires 4,500,000,000 years, radium only 1600 years. Other products formed in certain radioactive transformations are *very* short-lived, some lasting but a small fraction of a second before changing into still another substance.

The time is so short that it cannot be observed, but must be found by calculation.

STRUCTURE OF ATOMS

To realize how it is possible for an atom to undergo any change in its nature one is aided by an understanding of the theory of atoms worked out by Rutherford and Bohr. Each atom from the lightest to the heaviest they regarded as similar to a miniature solar system; a relatively heavy nucleus, like the sun, at the center, and lighter electrons, like planets, circling about it. Hydrogen, the lightest atom, has the simplest nucleus, called a proton, with one positive electric charge, and a single encircling electron of one negative charge going around it. The nucleus is 1845 times as heavy as the electron, so nearly all the mass of the atom is at the center (as is true of the solar system).

The nucleus of the other atoms is thought of as being composed of enough protons to give it its observed atomic weight, sealed together in some unknown way, perhaps by a *smaller* number of electrons so as to leave it with a net positive charge.

For instance helium has four protons in its nucleus giving it a weight of about 4, and these seem to be held together by two negative electrons, cutting down its *net* positive charge from four to two. It therefore requires two more electrons circling around the nucleus to make the whole atom electrically neutral.

Other heavier atoms are similarly constructed, up to the heaviest, uranium, which has a weight of 238, requiring 238 protons, and a net positive charge of 92, making 146 electrons necessary *in* the nucleus and 92 *around* it.

One or more of the outer ("planetary") electrons may be temporarily lost from the atom due to various causes which might be termed accidents, in which case the atom is no longer neutral, and is said to be ionized. It is the same atom, however, and may regain its lost electrons. But if an electron or other particle is removed from the nucleus the identity of the atom is lost, it becomes an atom of some other substance.

This conception of the atom, though it has been and still will be very helpful, may require some modification as new facts are learned. Only recently other entities than the positive proton and negative electron have been discovered. Evidence of a few *positive* electrons has been seen. The name "positron" has been applied to these. Also what seems to be *uncharged* protons have been found. It is thought that these may be a close com-

bination of an electron and a proton, the two charges neutralizing each other. "Neutron" seems an appropriate name for the uncharged particle, and its place in the periodic table should be in column zero, with the other elements that have no *valence* electrons, and whose valence is therefore zero. That is, they have no power to unite with any other element to form a compound. The "atomic number" of neutron must also be zero for this number represents its nuclear charge and its outside electrons.

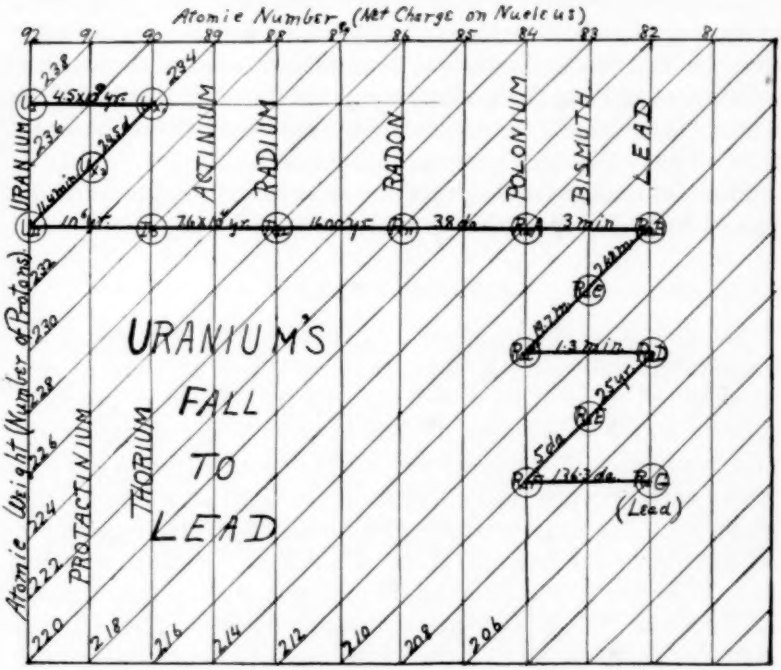
NATURE OF THE EXPLOSION

It is among the elements having the heaviest atoms that radioactivity is found. Lead and all elements lighter than it are stable, or almost so. A few of the lighter ones have been found to be very weakly active. These heavy atoms do not fall to pieces all at once like the famous one horse shay. The explosion that wrecks them does not send them flying in all directions like shrapnel from a shell, but it sends off one tiny piece. Returning to the illustration, a bolt or a hub cap is lost. Then what is left of the atom will rest for a longer or shorter period of time depending on which of the elements it happens to belong to after which it will repeat the same kind of explosion, with the same results.

The fragment expelled from an atom may be one of two things (see diagram); either it is an electron, the lightest of all known particles, or it is the nucleus of the helium atom, a particle thousands of times heavier than an electron but very small compared with the whole atom. In either case what remains of the atom rearranges its parts to form a new and different atom. The helium nucleus that is sent off picks up two electrons, always to be found floating about ready to be captured, and becomes an atom of helium gas. Thus at least one, and often two new atoms are produced at each explosion.

The well known gas helium, as explained above, is certainly one of the products of radioactivity, but what are the substances *left* as the atom by successive explosions shakes itself free of helium nuclei, which we will call alpha particles, or of electrons, called beta particles? As uranium "decays" it changes through a series of more or less transient substances until the stable element lead is reached. Actinium goes through another series of changes, ending in lead, and thorium through still a different set of transformations, but all three finally reach the same destination, they all become lead.

The element radium is one of the way stations between the head of one series, uranium, and the final product, lead. But many of the transient products are given such names as uranium X, radium A, B, C, etc. These products of decay are not varieties of uranium, radium, etc. Are they, then, *elements* of some other kinds? And if so, do they not increase the list of elements far above the limit of 92?



The loss of a helium nucleus lowers the atom 2 in atomic number and 4 in atomic weight, as from U to Th.

The loss of an electron raises the atom 1 in atomic number and does not change its atomic weight, as from Thorium to Protactinium, UX_I to U_{II}.

Questions such as these early led to a knowledge of the surprising fact that some of the radioactive elements are, like compounds, made up of different substances.

The different materials that make up a compound are called elements, the substances that constitute an atom are called isotopes of that atom. Soddy, a scientist in the Cavendish laboratory of Cambridge where radioactivity was being studied, coined this name isotope "same place" to indicate the fact that all the isotopes of an element occupy the *same place* in the Mendeléeff

table of elements. And if the substances occupy the same place in the table they must be identical chemically. Isotopes then, are substances that behave exactly alike chemically and yet are different in some other respect. They differ in weight for instance, and those that are radioactive differ in the length of time they last and in the nature of their disintegration into other elements.

Lead, for example, exists in three forms, that made from uranium has an atomic weight of 206, actinium lead is 207 and thorium lead 208. Ordinarylead contains a mixture of these three substances and has the average weight of its constituents 207.2. These three cannot be separated by chemical means because they all have the same chemical properties.

Many of the lighter elements also have been found to be made up of several isotopes of different weights.

AN ISOTOPE DETECTOR

An electro-magnetic apparatus invented by Dr. Aston of Cambridge University is the means by which an element can be analyzed to see if its atoms are all alike. It is very properly called a *mass spectrograph,* for just as an ordinary spectrograph makes a picture of the spectrum of light coming from a gas and shows each separate wave length in the light as a line on the plate, so in the mass spectrograph atoms of a certain mass are all focused in one line and those of a different mass in another line. If the gas has but one kind of atoms only one line is made on the plate. But if there are atoms of various weights a line is made for each, the lines differing in intensity depending on the relative amounts of the various substances present.

Chlorine is shown by chemical means to have an atomic weight of 35.46, but if this gas is put through Aston's mass spectrograph no line shows at the position 35.46 on the photographic plate, but there is one at 35 and another weaker one at 37. Likewise neon, whose atomic weight is 20.2, shows a strong line at 20, and a weaker one at 22, but none at 20.2. There are no atoms weighing 20.2 or 35.46. Chlorine and neon, like many other elements are made up of two or more kinds of atoms whose masses are whole numbers (or very nearly whole numbers). That is there are two kinds of chlorine, two kinds of neon, and two or more kinds of many of the elements, all acting alike chemically but of different weights.

TYPICAL DIVISIONS OF NINTH YEAR ALGEBRA

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This paper is a report of the findings in a recent study made by the writer and suggests some trends in our modern ninth-year algebra course. Evidence is presented indicating the extent to which general divisions constitute an elementary course in algebra and the nature of the changes that have been effected within recent years.

In order to facilitate the gathering of the data a scoring device was made upon which it was possible to collect the number of exercises and problems that could be classified into the twenty-six general divisions found in the fourteen elementary texts that were examined. For the most part the titles to the various divisions were: arithmetic (not as a title in any book), equations, evaluation, exponents, algebraic expressions, factoring, formulas, fractions, fundamental operations using only the plus sign of operation (not found as a separate title), graphs, imaginaries, signed numbers, parentheses, powers, proportion, radicals, ratio, review exercises, roots, series, special products, supplementary material, trigonometry, variation, verbal problems, and geometry constructions (not as a separate title).

The authors varied much in the volume of material, based on the number of exercises and problems, put into each Division. The percentage of such material found in the books will be presented. In Table I, the term "Highest" means the highest percentage of exercises and problems found in one book for the Division of the course specified; "Lowest" means the lowest percentage of exercises and problems found in another text; "Ratio" means the approximate ratio between the highest percentage for the Division and the lowest. It should be understood that the same book may have had the highest percentage of exercises and problems for only one, two, or a few of the divisions; the lowest percentage, for one, two, or a few; and in most instances was at neither extreme for most divisions.

In fourteen textbooks examined, more than one-eighth million exercises and problems were counted, classified, and recorded. The total number of such units of material counted for each

Division follows: arithmetic, 4958; equations, 19059; evaluation, 2280; exponents, 3763; algebraic expressions, 3131; factoring, 5566; formulas, 4127; fractions, 8824; fundamental operations using only the plus sign of operation, 1741; graphs, 2745; imaginary numbers, 433; signed numbers, 12876; parentheses, 3758; powers, 1032; proportion, 907; radicals, 5061; ratio, 1066; review exercises, 14256; roots, 3613; series, 750; special products

TABLE I
PERCENTAGE OF TOTAL NUMBER OF EXERCISES AND PROBLEMS IN EACH TEXT DEVOTED TO THE DIVISION INDICATED AS FOUND IN FOURTEEN NINTH-YEAR ALGEBRA TEXTBOOKS

No.	Division Titles	Percentage		Approx. Ratio
		Highest	Lowest	
1	Arithmetic	5.78	2.12	27 to 10
2	Equations	21.80	10.60	21 to 10
3	Evaluation	3.40	.82	41 to 10
4	Exponents	9.10	1.30	70 to 10
5	Algebraic expressions	5.00	.40	125 to 10
6	Factoring	6.60	1.55	43 to 10
7	Formulas	5.70	1.28	45 to 10
8	Fractions	10.80	4.10	26 to 10
9	Fundamental operations (plus)	3.30	.40	83 to 10
10	Graphs	4.50	.22	200 to 10
11	Imaginaries	1.62	.00	—
12	Signed numbers	15.80	7.10	22 to 10
13	Parentheses	4.15	2.16	19 to 10
14	Powers	1.80	.00	—
15	Proportion	1.60	.21	76 to 10
16	Radicals	5.40	1.60	34 to 10
17	Ratio	2.10	.21	100 to 10
18	Review Exercises	30.00	5.00	60 to 10
19	Roots	4.60	1.75	26 to 10
20	Series	3.10	.00	—
21	Special Products	4.05	.53	76 to 10
22	Supplementary Material	14.00	1.30	108 to 10
23	Trigonometry	7.20	2.50	29 to 10
24	Variation	1.12	.25	45 to 10
25	Verbal problems	16.00	3.97	40 to 10
26	Geometry Constructions	.86	.00	—

3118; supplementary material, 5397; trigonometry, 5059; variation, 766; verbal problems, 10700; and geometry constructions, 185; or a grand total of 125,171.

More than one-fourth of the material of a ninth-year algebra course occurs in two Divisions—equations and review exercises.

Fifty per cent of the material is found in five Divisions—the two just named and signed numbers, verbal problems, and fractions. Three-fourths of the exercises and problems in the typical ninth-year algebra are to be found in eleven of the twenty-six divisions. Ninety per cent of the material is allocated to sixteen of the divisions—that is, in fifty-nine per cent of the divisions. The ten remaining divisions contain only ten per cent of the material but absorb forty-one per cent of the classification into divisions.

When the Divisions are expressed in percentages and are based on all of the material the following results are recorded: equations, 15.23; review exercises, 11.33; signed numbers, 10.32; verbal problems, 8.51; fractions, 7.06; factoring, 4.45; supplementary material, 4.32; radicals, 4.04; trigonometry, 4.02; arithmetic, 3.94; formulas, 3.28; parentheses, 3.03; exponents, 3.02; roots, 2.92; algebraic expressions, 2.55; special products, 2.52; graphs, 2.24; evaluation, 1.82; fundamental operations using only the plus sign of operation, 1.38; ratio, .85; powers, .82; proportion, .72; variation, .61; series, .38; imaginaries, .34; and geometry constructions, .15.

The Division, Equation, is divided into 13 topics, of which two topics make up more than fifty per cent of the Division; or four of them eighty per cent. Expressed as percentages of the material of the Division, the four topics are: linear equations, 33.77 per cent; quadratic equations, 19.42 per cent; simultaneous solutions, 16.04 per cent; and equations with fractional coefficients, 13.30 per cent.

The Division, Review Exercises, consisted of five topics or parts, namely: tests and practice tests; exercises placed at the end of the chapter; after natural divisions in the chapter; at the end of the book; and at the end of several chapters. The first two types of topics constitute nearly seventy per cent of the material of this Division.

In the Division, Signed Numbers, there were eleven topics. In two of them was found 49.65 per cent of the exercises and problems of this Division. These two topics and their proportionate percentages of the Division are: monomials involving either multiplication, division, addition, or subtraction, 30.05 per cent; polynomials in multiplication, division, addition or subtraction, 19.60 per cent. Two other topics increase the percentage to more than seventy-five per cent of the Division. These are; fractions involving fundamental operations. singly

and combined, 15.50 per cent; and, exercises actually requiring the use of parentheses, 10.30 per cent.

Twenty-two types are included in the division bearing the title, Verbal Problems. These are: miscellaneous, géometry, number (value, amount, etc.), motion, business (profit, loss, cost, investment, etc.), application of formulas, trignometry, work, ratio, proportion, variation, coin, digit, mixtures, series-progressions, age, lever, physics-engineering, gravity, density, clock, and volume. The first three compose fifty-five and four-tenths per cent of the Division, and expressed in percentages they are respectively as follows: 26 per cent; 14.90; and 14.50.

The Division, Fractions, is made up of eleven topics, of which four constitute seventy per cent of the material of the Division. These four are: equations used in stressing fractions, 28.40 per cent; fractions involving combined fundamental operations 17.20 per cent; reduction of fractions, 12.99 per cent; exercises involving L.C.D., L.C.M. and H.C.F., 10.20 per cent.

The Division, Factoring, consists of ten topics. Based on the number of exercises and problems in the Division, two of the topics constitute 59.8 per cent of it, and four of them more than 82 per cent. The first four topics and their percentages of the Division are: quadratic trinomials, 38.8; difference of two squares, 21.0; combination of cases, 11.60; monomial factor only, 10.02.

The Division, Supplementary Material, consists of 28 topics. This section seems to have been designed by the authors for the purpose of enriching their textbooks. Ten of the 28 topics in this Division constitute, each, 1 per cent or less of the exercises and problems of the Division, and make a total of less than 10 per cent. The principal topic is called "General Review" and consists chiefly of unclassified exercises. Its percentage of the Division is 15. No other of the 28 topics exceeds 10 per cent of this Division.

The Division, Radicals, is composed of eleven topics, of which two constitute 56.5 per cent of the Division. These are: fundamental operations with radicals, 36.1 per cent; reduction of radicals consisting of whole quantities, 20.4 per cent.

In the Division, Trigonometry, there were twelve topics. Three of them contain 45.7 per cent of the exercises and problems in the Division. These three are: exercises on the use of the tables, 20.57 per cent; exercises requiring interpolation, 13.89 per cent; and exercises built around the use of the tangent, 11.24 per cent.

In the Division, Formulas, three of the ten topics constitute 50.2 per cent of the material in it. Exercises dealing with areas, 24.2 per cent; series-progressions, 13.8 per cent; business (interest, percentage, brokerage, etc.), 12.2 per cent; physics-engineering, 11.2 per cent; and volumes, 10.8 per cent, are the leading topics.

There are six topics in the Division, Parentheses. In the order of rank expressed as a percentage of the exercises and problems in the Division, they are: used in fundamental operations, 23.8; used in fractions, 23.6; used in equations, 17.6; removal of parentheses, 14.8; with radicals, 14.2; and inclosing terms in parentheses, 6 per cent.

The Division, Exponents, consisting of eight topics has 50.1 per cent of the material in two of them. The topics in order of percentages of the Division are: multiplication law, 33.4; division law, 16.7 per cent; fractional exponents, 16.2; root law, 11.8; negative exponents, 9.15; change to radicals, 6.85; literal exponents, 3.18; zero exponents, 2.56.

Of the nine topics that constitute the Division, Roots, two of them compose 48.2 per cent of the material; and three give 69.9 per cent. The first three types are: exercises using arithmetic for explanations of processes for practice and for utility, 24.6 per cent; exercises stressing "roots of an equation," character of a root, and including verbal problems, 23.6 per cent; exercises on roots obtained by dividing exponents by the index of the roots, 21.7 per cent.

Two topics of the Division, Special Products, compose 62.1 per cent of the material of the Division; three of them 81.2 per cent. There are seven topics in all. Four (each) have decidedly more material than any of the remaining. The seven and their percentages of the Division are: two binomials having a common term, 34.8 per cent; square of binomial, 27.3; sum and difference of two numbers, 19.1; exercises in arithmetic, 11.9; binomial theorem, 4.2; two binomials not having a common term, 1.50; and, square of polynomial, 1.0.

The Division, Graphs, has eight topics. Two of them have 51.1 per cent of the material of the Division. Equations and formulas compose 31.9 per cent; and the single quadratic equation 19.2 per cent.

The Division, Evaluation, has three parts. Exercises dealing in evaluation occur 40.2 per cent of the time. Evaluation of formulas constitutes 33.68 per cent of the exercises of the Divi-

sion. Teaching the use and understanding of exponents occupies 25.8 per cent of the Division.

The Division, Fundamental Operations involving only the use of the plus sign of operation, has six topics. Three of them have 93.63 per cent of the exercises of the Division. They are: monomials in multiplication, division, addition, and subtraction, 62.5 per cent; monomials (combined fundamental operations), 15.8 per cent; polynomials in multiplication, division, addition, and subtraction, 15.33 per cent.

The Division, Ratio, has four topics. Exercises in ratio including verbal problems stressing ratio constitute 32 per cent of the Division.

The Division, Powers, has seven topics. The first two topics contain 45.2 per cent of the material of the Division. Exercises in evaluation lead with 24.2 per cent; and monomial squares come next with 21.2 per cent.

In Division, Proportion, there were four topics. Seventy-five per cent of the material on proportion is in the topic, exercises stressing proportion. Eleven and three-tenths per cent ot the exercises and problems are arithmetical.

The Division, Variation, has six topics. The first two contain 63 per cent of the material of this Division. These topics are: exercises stressing dependence 33.4 per cent; direct proportion, 29.6 per cent.

In the Division, Series, there were six topics. Three of th topics contain 81.2 per cent of the material of this Division. The first, arithmetic progression 30 per cent; the second, geometric progression, 27.4 per cent; and the third, binomial expansion, 23.8 per cent.

It is not possible, in such a short paper, to here present all of the data for an accurate picture and only a portion has been given, but it is hoped that the dominant Divisions and their topics will serve as a guide to the nature of ninth-year algebra. The conclusions that follow are based on the complete data and crystallize in brief the essence of the whole study.

CONCLUSIONS

1. Textbook writers of ninth-year algebra are in agreement on the general divisions of mathematics. The divisions supported by at least 12 of the 14 texts arranged in order of percentage rank were:

Equations	15.23
Review Exercises	11.33
Fundamental operations with signed numbers	10.32
Verbal problems	8.51
Fractions	7.06
Factoring	4.45
Supplementary material	4.32*
Radicals	4.04
Trigonometry	4.02
Arithmetic	3.94
Formulas	3.28
Parentheses	3.03
Exponents	3.02
Roots	2.92
Algebraic expressions	2.55
Special products	2.52
Graphs	2.24
Evaluation	1.82
Fundamental operations using only the positive sign of operation	1.38
Ratio	.85
Powers	.82
Proportion	.72
Variation	.61

* Found in only 10 of the textbooks.

2. Effective drill in arithmetic is carried on throughout the ninth-year algebra course and is found taught incidentally in all the textbooks examined. This tendency is in keeping with the National Committee recommendation of the subject of arithmetic.

3. There are more exercises and problems in the division, termed Equations, than in any other.

4. The percentage of equations in a course in ninth-year algebra has remained constant for the last fifteen years.

5. Evaluation, as a division, has been considered necessary because it offered: numerical practice; a better understanding of algebraic processes and symbols; an opportunity to retain previous numerical proficiency; and functional thinking in connection with graphical work.

6. There is no agreement in the fourteen textbooks as to the percentage of the course that algebraic expressions should constitute.

7. The volume of material devoted to the teaching of exponents is decidedly less than it was fifteen years ago. It was found to be only three-eighths the percentage Rugg and Clark found in 1918.

8. Textbook writers show a definite tendency to offer less formal exercises in factoring than previously existed. Only 37.4

per cent of what Rugg and Clark[1] found in 1918 now exists.

9. Seven general types of formulas include about ninety per cent of the exercises on the use of formulas. The authors link formulas closely with evaluation, graphs, equations, and literal equations.

10. Formal exercises in fractions maintain about the same percentage of the course that they did fifteen years ago. Rugg and Clark[1] found this percentage to be 7.2. In this study it was found to be 7.06 per cent.

11. In any set of formal exercises involving any of the fundamental operations the tendency is to select as the first two or three such as require the use only of the plus sign of operation.

12. Exercises that specifically require geometry constructions are almost negligible. However, many exercises of a geometric nature are offered for which a geometrical figure is unundoubtedly expected.

13. The percentage of work on graphs is approximately the same as that demanded fifteen years ago. There is less tendency to treat graphs as a separate topic and a marked tendency to teach them in connection with equations, formulas, variation, and dependence.

14. The tendency in ninth-year mathematics is to refrain from including exercises on imaginaries.

15. The trend in the use of parentheses is to avoid elaborate exercises and to stress their functions while teaching manipulations.

16. There is a tendency to offer some work in powers over and above such geometrical quantities as the volume of a cube.

17. Little space is devoted to proportion and there need be no increase in this material.

18. Formal exercises on radicals have decreased to less than fifty per cent of what Rugg and Clark[1] found in 1918.

19. Exercises on the use of ratio have decreased slightly and are in keeping with the National Committee recommendation that they be of "Various simple applications."

20. Review exercises are a necessary part of the ninth-year algebra textbook, amounting to about one-ninth of it and supported by all writers.

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[1] Rugg, Harold O., and Clark, John R. *Scientific Method in the Reconstruction of Ninth-Grade Mathematics*, pp. 27–36. Supplementary Educational Monographs, Vol. II, No. 1. Chicago: University of Chicago Press, 1918.

21. There is a very slight tendency to teach series in ninth-year algebra but no trend.

22. The National Committee[2] recommended the omission of the square root of a polynomial. This has not been done as 12 of the 14 textbooks supported the topic to the extent of 10 per cent of the division (Roots).

23. Formal exercises on special products have decreased more than fifty per cent in the past fifteen years. In 1918 Rugg and Clark found this division to be 5.8 per cent of the course. The present study shows 2.52 per cent.

24. There is a tendency among writers of ninth-year textbooks to include a division called supplementary material. Seventy-one per cent of the texts had such a section and the average percentage was 4.32.

25. Trigonometry is definitely a part of the ninth-year algebra course. Exercises using the tangent function occur more frequently than do those of sine and cosine. This is in agreement with the findings of Dhus.[3]

26. Exercises on variation are of four general types, i. e., those stressing (1) dependence, (2) direct variation, (3) inverse variation, and (4) graphical relations.

27. Stressing of fundamental operations, using the negative sign, as mere formal exercises is getting less support than in the past. Applications of the principles are on the increase.

28. Verbal problems are of twenty-one general types.

[2] *The Reorganization of Mathematics in Secondary Education.* A Report by the National Committee on Mathematical Requirements. Washington: Mathematical Association of America, Inc., 1923. Pp. X+652.

[3] Dhus, Mabelle Dorothy. "A Determination of the Tendencies of Junior High School Mathematics." Unpublished Master's thesis, Department of Education, University of Chicago, 1927. Pp. V+78.

BOTTLE DRIFTS SEVEN YEARS ON LONG SEA WANDERINGS

Drifting a distance probably more than a third of the earth's circumference, a sealed bottle tossed from the bridge of the American steamer Hahira more than seven years ago was finally washed ashore on the coast of Texas, states a report to the Hydrographic Office of the U.S. Navy.

The paper in the bottle showed that it had been launched by Second Officer A. C. Barstow of the Hahira on April 20, 1927, in latitude 30 degrees 24 minutes north, longitude 79 degrees 35 minutes west. This is between the Bermudas and the southern Atlantic coast of the United States. The ocean currents, however, flow in a direction that would preclude its drifting directly to the point where it was found. More probably it made the entire circuit of the North Atlantic, through the Caribbean and into the Gulf of Mexico, covering an estimated distance of 8,800 miles on its long and lonely voyage.—*Science Service.*

A DEVICE FOR DETERMINING FREQUENCIES

By A. W. Stewart
Kent State College, Kent, Ohio

The stroboscopic disk is a simple but very useful device in the physics laboratory. It can be used for determining the frequency of alternating current, of tuning forks or vibrating strings. The additional apparatus necessary is a rotator, preferably electric, or, if that is not available, a phonograph. The rotator should be equipped with a counter but this is not necessary in the phonograph since its slow motion permits counting by observation.

The disk shown below is for use with the electric rotator. It is cut from white cardboard, is six to nine inches in diameter and is divided into three rings, each ring being divided into sectors. The outer ring has 36 double sectors, each double sector being made up of one black and one white sector. The next ring has 18 double sectors and the inner ring 9. A disk divided into 18 double sectors answers the purpose very well but the extra rings make the disk adaptable to a wider range of speeds and also enable the experimenter to check the results of one ring against another. The sectors should be laid off very accurately with the aid of a large protractor and each alternate sector blackened with India ink. The disk should be accurately centered and punched. If this precaution is not observed the resulting eccentric motion will interfere with the stroboscopic effect.

To find the frequency of a tuning fork the disk is attached to the electric rotator, one student holding the vibrating fork over the rotating disk so that the former is observed against the background of the rotating disk. For this purpose the disk is rotated in a horizontal plane. The fork is held tangent to the rotational direction of the disk as shown in the drawing. The student holds the fork in his right hand and adjusts the speed of rotation with his left hand. As the speed is varied the observer finds a point at which waves or ripples appear to run along the prongs of the fork. If the disk is turning too fast the waves move in the direction of rotation, if too slow they run in the opposite direction. By careful adjustment a speed can be found at which the waves appear stationary. When this is found the second student simultaneously starts a stop watch and engages the counter. The first student holds the speed, occasionally checking it by striking the fork against a rubber pad and bringing it

into position over the disk. The accuracy is dependent upon the time of the count but good results are obtainable in 90 seconds. Variation from this time will depend upon the desire for accuracy.

The computation is made from the following equation in which n is frequency, R is the number of rotaitons in the time used and S is the number of sectors in the ring used:

$$n = \frac{R \times S}{t}.$$

The computation is simplified if the time is made a multiple of the number of sectors used. Below are shown the results for a standard fork of 435 vibrations. Since it *is* a standard fork the results may be taken as a measure of the accuracy of the method:

	First trial	Second trial
Initial counter reading	91430	89250
Final reading	89253	88162
Number of rotations	2177	1088
Time in seconds	180	90
Numbers of sectors used	36	36
Frequency	435.4	435.2

To determine the frequency of a string the same procedure is used except that some arrangement is necessary for stretching the string across the face of the disk. For this purpose the disk may rotate either in a vertical or horizontal plane. If it is horizontal the string is made fast at one end and is run over a small pulley at the other. In this case there is always a negative error of about 1% in the observed frequency as compared to the theoretical frequency, due apparently to friction in the pulley. If the string is vertical there should be a clamp at the lower end as well as the upper end, otherwise it is difficult to determine the exact length of the string. The lower clamp should be tightened only enough to prevent vibration below the clamp.

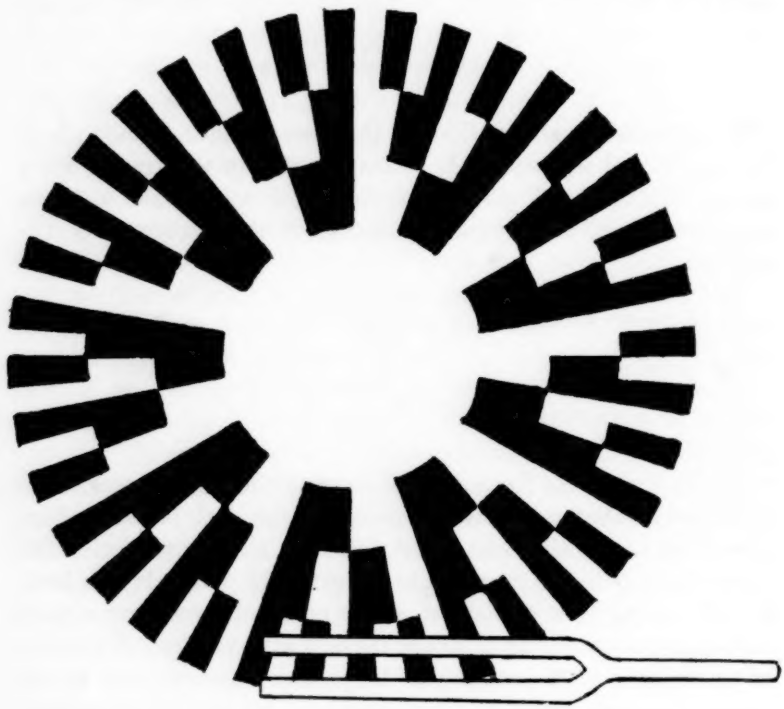
Using a string (wire) having a linear density of .0113 grams, a length of 72.7 cm., and a tension produced by 1,600 grams, the experimental count gave 80.0 for one trial and 79.9 for a second trial. The theoretical determination from the equation,

$$n = \frac{1}{2L} \cdot \sqrt{\frac{T}{d}}$$

gives 81.0.

To determine the frequency of the alternating current the

disk is rotated under a lamp attached to the current supply. A neon light is best for this purpose but not absolutely necessary as an ordinary electric light bulb will give satisfactory results. The speed of the rotator is adjusted to the lowest point at which the disk appears to be stationary. This is the speed at which each black sector moves up exactly one double sector space



between the flashes of the light. Since the light flashes twice for each complete cycle of current the frequency will be:

$$n = \frac{R \times S}{2t}.$$

Two such determinations gave 60.2 and 60.1. Since the current frequency is exactly 60, this may also be taken as a measure of accuracy of the method.

If an electric rotator is not available it is usually easy to get a discarded phonograph. The one requisite is that it have a good governor. The disk for such a machine must be divided into a larger number of sectors and is therefore more difficult to make.

However, a disk ten inches in diameter can have an outer ring of 360 double sectors, a second of 180 and an inner ring of 90. With such a disk all the experiments mentioned above can be worked out very accurately. There are two advantages here over the rotator. First, the speed is very accurately regulated and second, when it has been regulated the experimenter may leave the speed as regulated and make the count without an assistant.

High school students are interested in the stroboscopic effect. They are puzzled by it as seen in motion pictures when the automobile wheels appear to turn backwards. Since it involves an understanding of the eye as well as light it is all the more interesting. For that reason it is perhaps best to present the current determination first so the pupil may understand the principle before doing the other experiments with the forks and strings. In the case of the string, alternating light effect is provided by the black and white sectors. One sees the string over the white, not over the black sectors. Furthermore the string is most plainly seen at its greatest amplitude since it is more nearly at rest at that point. If, during the time of one complete vibration of the string, a white sector moves away and another white sector exactly replaces it, the segment of the string over the white sector will appear not to move. If the second white sector is late in arriving at the position of the first the segment of the string will appear to move backward. If the second sector arrives before the completion of one period of the string the segment will appear to move forward.

The experiment to determine frequency of the current must obviously be done in artifical light. The other two are better in sun light.

SIGMA ZETA

The Annual Konclave of the Sigma Zeta, a national honorary science society, was recently held at Westerville, Ohio.

Officers for the ensuing year were elected as follows: Grand Master Scientist, H. W. Olson (Eta); State Teachers College, Mansfield, Pa.; Vice Grand Master Scientist, E. E. List (Alpha), Alton, Illinois; Grand recorder-Treasurer, T. A. Rogers, (Zeta), Stevens Point, Wisconson; Grand Historian, S. M. McClure (Beta), Lebanon, Illinois; Grand Editor, Marvin C. Meyer (Eta), Cape Girardeau, Missouri.

A very interesting program was given, the outstanding feature of which was an address on "Human Inheritance, with Special References to Blood Groupings" by Dr. L. H. Snyder of the University of Ohio.

EASTERN ASSOCIATION OF PHYSICS TEACHERS

One Hundred Twenty-Seventh Meeting

Worcester Polytechnic Institute

Worcester, Mass.

Saturday, May 5, 1934

MORNING PROGRAM

9:30 Meeting of the Executive Committee.

9:45 Business Meeting.
- Annual Report of the Secretary.
- Annual Report of the Treasurer.
- Report of the Nominating Committee.
- Election of Officers.
- Reports of Committees.

10:15 Address of Welcome: President Ralph Earle, Worcester Polytechnic Institute.

10:30 "Devices for Teaching Wave Motion." Dr. A. W. Duff, Department of Physics, W. P. I.

11:00 "Some Novelties in Light and Sound." Dr. Robert H. Goddard, Department of Physics, Clark University.

11:35 "New Light on Cosmic Rays." Dr. Richard A. Beth, Department of Physics, W. P. I.

12:10 Three Simultaneous Demonstrations. Take your Choice.
- (a) "Photoelastic Study of Stresses." Dr. M. L. Price, Mechanical Engineering Department, W. P. I. Mechanical Engineering Building.
- (b) "New Apparatus for Lecture Demonstrations of Wave Forms in Alternating Currents." Prof. H. H. Newell, Electrical Engineering Department, W. P. I. Electrical Engineering Building.
- (c) "A New Method of Testing the Law of Force between Charges" and "A Demonstration of the Barkhausen Effect in Magnetism" (makes magnetization audible), Drs. S. J. Plimpton and W. E. Lawton, Departments of Physics, W. P. I.

1:00 Luncheon at the Dormitory. Price 60 cents.

AFTERNOON

Visit to the Worcester Polytechnic Institute Hydraulic Testing Laboratory at Chaffins. This is a very extensive and well equipped plant and will be of interest to all. Explanations will be given by Prof. Charles M. Allen, who developed the plant.

OFFICERS OF EASTERN ASSOCIATION OF PHYSICS TEACHERS

President, Louis A. Wendelstein, High School, Everett, Mass.
Vice-President, Hollis D. Hatch, English High School, Boston, Mass.
Secretary, William W. Obear, High School, Somerville, Mass.
Treasurer, William F. Rice, Jamaica Plain High School, Boston, Mass.

REPORT OF THE TREASURER, 1933-1934

Balance from 1932–33		$309.87
Receipts:		
Dues, Active 1931–32	$ 1.00	
1932–33	6.00	
1933–34	283.00	
Assoc. 1932–33	3.00	
1933–34	85.00	
1934–35	1.00	
Total dues	379.00	
Interest	10.61	389.61
		699.48
Expenditures:		
Printing and stationery	32.95	
Postage	20.85	
Clerical work		
Treasurer	23.00	
Secretary	4.99	
Salary of Secretary	50.00	
Expense of meetings	1.50	
Tax on checks	.46	
Subscriptions to SCHOOL SCIENCE and MATHEMATICS	238.00	371.75
Balance forward		327.73
Gain for the year	17.86	

ASSETS

First National Bank of Boston, Savings department	$273.28
First National Bank of Boston, Commercial department	44.80
Cash	9.65
	327.73

Respectfully submitted,

WILLIAM F. RICE, *Treasurer*

May 4, 1934. Examined and found correct.

CHARLES S. LEWIS, *Auditor*

ANNUAL REPORT OF THE SECRETARY

Since the last annual meeting we have held three meetings as follows:
the 125th, Dec. 16, 1933, at the High School, Arlington, Mass.
the 126th, March 17, 1934, at Radcliffe College, Cambridge, Mass.
the 127th, May 5, 1934, at Worcester Polytechnic Institute, Worcester, Mass.

The programs have been interesting and the speakers well chosen both for knowledge of their subjects and their ability to present them to us in an interesting and understandable form.

We have, as in previous years, for part of these meetings joined with the New England Section of the American Physics Society.

It was our privilege also to be closely associated with the meetings of the American Association for the Advancement of Science which met in Cambridge in December 1933.

Our special contribution at that time was the preparation of an exhibit illustrating the teaching of Physics in our schools. The exhibit included

charts, illustrative material, teaching devices and apparatus, devised and constructed by our members and their pupils.

This exhibit was very favorably commented upon and much credit is due Mr. Hollis Hatch who had charge of its preparation and the other members of our Association who contributed material and services.

Our present membership is 171. There are 114 active members, 55 associate members, and 2 honorary members. This is 7 less than we had at the last annual meeting. While this is not in itself a large shrinkage, it does appear that as the times are improving in every way we should look for a considerable increase instead of decrease in our membership next year.

The Secretary believes that it is our duty to the teaching profession to see to it that many more of the younger Physics teachers should be brought within the influence of this organization.

Respectfully submitted,
WILLIAM W. OBEAR, *Secretary*

The nominating committee, Mr. Hollis Hatch, Chairman, Mr. Homer LeSourd, and Mr. Kenneth Goding, presented the following candidates and they were elected to serve for the ensuing year.

President: William E. Smith, English High School, Boston, Mass.

Vice-President: Joseph M. Arthur, St. Mark's School, Southborough, Mass.

Secretary: William W. Obear, High School, Somerville, Mass.

Treasurer: Preston W. Smith, Rivers School, Brookline, Mass.

Executive Committee: Ralph H. Hauser, Belmont, Mass.; Carroll H. Lowe, High School, Brookline, Mass.; Clarence W. Lombard, High School, Hyde Park, Mass.

President Wendelstein spoke in appreciation of the support he had received from all the officers, chairmen of committees and members, thanking everybody for their compliance with his requests and their fine cooperation.

Upon motion of Mr. Cushing it was voted that the sincere thanks of the Association be tendered to the retiring Treasurer, Mr. William F. Rice, for his many years of faithful service.

Mr. Cushing, Chairman of the Committee on College Entrance Requirements, reported that he had sent to the College Entrance Examination Board a copy of the recommendations adopted at our 125th meeting and had received a reply acknowledging its receipt and stating that the communication had been referred to the proper committee.

It was voted that the thanks of the Association be extended to Worcester Polytechnic Institute for their hospitality in providing facilities for this meeting and entertaining us as guests at the luncheon. Thanks were also voted to the speakers and to others who helped in preparing and carrying out the program.

Mr. Charles B. Harrington of the Newton High School presented the following interesting results of a questionnaire given in that school. Figures in the first column are from college preparatory pupils and in the second column from non-college pupils.

1. Have radios in their homes	99. %	97.5%
2. Study while radio is turned on	44.	24.
3. State that the radio as used by members of their families has a harmful effect on their home study	19.6	17.5
4. Have no place to study out of hearing of the radio	10.	11.
5. State that radio has no effect on home study	67.	64.
6. State that radio has a helpful effect on home study	3.6	13.

7. Average time spent in listening to radio per day on "school" nights between supper and bed time 1 hr. 50 min., 2 hr. (about 8% average as high as 4 hours)
8. An idea of the programs listened to regularly each week may be gained from the following summary. Selecting the six most popular programs of dance and jazz orchestras, including comedians and crooners as group A and the six following programs, Cities Service, Cadillac hour, Radio city, bands, symphony orchestras, and operas, as Group B, the ratio of A to B stands 6.7 to 1 for the college preparatory pupils and 14 to 1 for the non-college pupils.

These results, Mr. Harrington believes, present much food for thought and a problem to be solved.

President Earle very heartily welcomed us to Worcester Polytechnic Institute. He spoke of the value of professional organizations which are closely knit together and which meet for discussion and the sharing of progress. He sketched some developments in the teaching of Physics giving credit to the teachers who lay the foundations which are indispensable to progress in engineering.

WAVE MOTIONS AND INERTIA

By Prof. A. W. Duff

Worcester Polytechnic Institute

In the teaching of wave motion, one of the most effective means of illustrating the principles involved is the projection, on a screen, of ripples in a shallow water tank with a plate glass bottom, by means of an arc light below the tank and an inclined mirror above. The effects are so striking and so interesting to a class that the method should be used more widely.

The propagation of spherical waves and the interferences of two systems of waves are readily shown. The laws of the reflection of plane waves and the equality of the angles of incidence and reflection are illustrated by reflection from a side of the tank. Refraction of waves can be illustrated by means of a glass plate immersed in the water and of a thickness equal to about half the depth of the water. If the plate is of the form of a central section of a lens, the changes of curvature of the waves on entering and leaving the second medium and the formation of foci by light passing through a lens are very clearly shown. Huygens' construction for explaining the propagation of wave fronts can be illustrated by a row of nails on a stick, each nail starting a secondary wavelet as it enters the water. Tilting the tank slightly, so that the depth of the water increases from one side to the other, shows the effect of the varying depth of the water on the direction of propagation of a wave front; and it explains why, at the seaside, ocean waves, with fronts at right angles to a beach, wheel around as they sweep up the beach.

Waggener's wave model (Central Scientific Co.) consisting of a number of rotating spiral wires, arranged in a lantern slide, illustrates the superposition of waves on wires and the addition of transverse waves in general in a very convenient and striking way.

Waves on wires and on the strings of musical instruments have a great variety of forms, depending on how the wire or string is bowed or plucked. These were illustrated by focussing an arc light on a wire and projecting an image of a point on the wire on the screen by means of a rotating mirror.

The propagation of waves depends on inertia of some kind, inertia of matter or electromagnetic inertia. Inertia is shown in a striking way by the bending and breaking of a tall tower as it falls. This was illustrated by a lantern slide of a falling tower that broke as it fell. The effect was reproduced by a small "tower" consisting of three sticks, standing one above another. The different ways in which the "tower" fell apart with different speeds of fall, depending on how the support was withdrawn, presented some interesting illustrations of inertia, moment of inertia, and moment of force.

SOME NOVELTIES IN LIGHT AND SOUND

By Prof. Robert H. Goddard
Clark University

SOUND PRODUCED BY BENT RUBBER TUBE

The natural vibrations of air columns are easily excited by unstable conditions at the ends. Thus if a rubber tube is slipped over the end of a glass tube, and is then bent at an angle of about 90° with the glass tube, and air is forced through under pressure, strong vibrations of the air in the tube will be produced. Tests have been made with glass tubes from $\frac{1}{4}''$ dia. and 4″ long to 1″ dia. and 6 feet long, using about 3 lbs. air pressure. The long glass tube gives both fundamental and harmonics, the latter being produced by applying tension to the rubber tube. Loud notes may be produced by bugles and coach horns, in the same way, the amplitude of vibration of the rubber being over 1/16″. Even a right angle bend in a rubber tube, alone, will produce sound in the air between the bend and the open end.

SOUND PRODUCED BY FLAMES

The familiar experiment of lighting gas above copper gauze, and holding tubes of various sizes, with one end touching the gauze, may be varied by using a glass tube, so that the flame is visible. The tip of the flame is yellow, and there is a green ring around the base of the flame, on the surface of the gauze. A spherical resonator, open at the opposite ends of a diameter, resonates well when placed on the gauze. Ignition of the gas below the gauze, in the case of very loud sounds, may be prevented by moving the gauze back and forth across the tube.

RESONANCE PRODUCED BY ELECTRIC FAN

The note produced by the fan may be brought out clearly by using a line of flames. This is produced by drilling small holes $\frac{1}{4}''$ apart in a tube about 6″ long, one end of the tube being plugged. When gas is admitted, and the tube is held vertically and at one side of the fan, with the flames pointing toward the fan, a loud note from the fan is produced.

A tube about 2″ in diameter is used to produce the resonance. If the note produced by the fan is called "do," the length of the tube should be such that, when closed at one end, the note produced by it is the "sol" next above this "do."

The tube should be held horizontally with one end close to, or touching, the rear guard of the fan, and should make an angle of about 45° with the axis of the latter, with the free end more distant from the axis than the end touching the guard.

If the hand is held close over the free end, a note will be heard corresponding to the "sol" above the "do" of the fan. Three notes of higher pitch will then be heard, as the hand is gradually removed from the free end of the tube, in the order "do," "mi," and "sol," the latter being an octave above the note produced when the end of the tube is closed. Thus the familiar bugle call "taps" may easily be played.

The simple theory of the open and closed pipe does not account for the two notes "do" and "mi." These are due to the impedance produced by the hand at the free end of the tube. The tuning is analogous to that of a radio aerial which has an electrical system at one end.

VIBRATION PRODUCED BY TEMPERATURE DIFFERENCE

Strong vibrations of bodies caused by touching them with a piece of dry ice, or solid carbon dioxide, have recently been discovered by Mary D. Waller, *Proc. Phys. Soc. of London*, 45, p. 101, 1933.

These may easily be demonstrated by high or low pitched tuning forks, the latter vibrating with the frequency of one of the harmonics. The gong of an electric bell rings when the edge is touched to the cake of dry ice, as does a bugle or an aluminum tube, touched at various places, preferably middle. When a piece of the dry ice is pressed against the center of a circular brass plate, supported by a wire through a hole 0.68 of the radius from the center, a sound resembling that of a fire gong is produced.

An interesting demonstration showing that gas is produced when warm metal touches the dry ice can be made in the following way: If a solid brass or copper sphere, $1\frac{1}{2}''$ dia., is pressed against a block of dry ice until it has sunk $\frac{1}{4}''$ or so into the surface, the pressure of the gas continuously produced will keep the sphere out of contact with the ice. The fact that the sphere is resting in a cushion of gas may be shown by spinning the sphere, when it will be found to revolve for a considerable time. A similar sphere that has not been cooled, placed in the same depression in the ice, will revolve even longer. The rotation is most striking if one side of the sphere is polished and the others side is dull.

EXPERIMENTS ON REFRACTION OF LIGHT

The following three pieces of optical apparatus have been manufactured by Max Kohl, Germany, for some time but are not often included in lecture equipment in the United States.

A closed glass tube having a glass rod extending from one end to the center is half filled with a liquid of the same refractive index as the glass. Inverting the tube causes the rod, apparently, to disappear.

A 60° glass prism has one edge cut into an irregular shape, and has flowers painted on the two sides, above the cut-out part. On looking into the face opposite the cut edge, a silver vase of flowers, all in relief, appears, due to reflection; the silver color of the vase being due to total internal reflection. The reflection is the same as that seen in two mirrors making an angle of 90° with each other, in which an observer sees himself without the reversal from left to right that occurs with a single plane mirror.

A black paper box, provided with a cover, has a hole in each of two adjacent sides. A clear glass cube fits in the box. When the cube is placed in the box, and the cover put on, no light can be seen through the two holes, owing to total internal reflection.

NEW LIGHT ON COSMIC RAYS[1]

By Prof. Richard A. Beth
Worcester Polytechnic Institute

DEFINITION

"Cosmic Rays" is the name of the ultimate cause of that part of the ionization of the atmosphere which cannot be ascribed to the rays of radioactive substances on earth nor to any other known agency. (K. K. Darrow, January, 1932.)

GENERAL

Definite attention was first turned to this "penetrating radiation" in the first decade of this century. Increasing interest on the part of physicists is shown by the fact that, since 1900, 140 articles on the subject have been published in each of successive intervals of 24, 5, 3, and 1½ years. (Kolhörster.) Rutherford has called it the most interesting phenomenon of modern physics. In 1932 well over one hundred physicists gave major research time to the study.

"The subject is unique in modern physics for the minuteness of the phenomena, the delicacy of the observations, and adventurous excursions of the observers, the subtlety of the analysis, and the grandeur of the inferences."—Darrow.

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[1] References to summaries on cosmic ray work:
K. K. Darrow: *Bell Syst. Tech. Journal*, Jan. 1932, Vol. XI, pp. 148–184
P. Auger: *Journal de Physique*, Jan. 1934, pp. 1–5.
W. Kolhörster: *Physikalische Zeitschrift*, 15 Nov. 1933, pp. 809–819.

METHODS OF OBSERVATIONS

(1) Ionization Chamber.—only method up to 1928.

The amount of ionization per cubic centimeter is determined by measuring the rate of discharge of an *electrometer* through a space containing the gas.

Only rapidly moving charged particles, called "r-rays" by Compton, can produce sufficient ionization to be detectable by this method. "R-rays" have a definite range and ionize the absorbing matter uniformly throughout that range. In general positive and negative electrons as well as ionized atoms would fall in this category. The special names of positron, negatron or beta particle, proton, deuton, alpha particle have been assigned respectively to the positive and negative electron, the nucleus of hydrogen isotope one (H^1 or proterium), isotope two (H^2 or deuterium), and of helium. Ionization of a gas by photons (quanta of radiant energy) and by neutrons is insufficient to affect the electrometer directly.

Results depend upon chamber shielding, gas, gas pressure, local ionization, etc., as well as on effect to be measured. These factors have been extensively studied. This method apparently favors the softer or less penetrating components of cosmic rays. (Kolhörster.)

The ionization in normal air at sea level due to cosmic rays is between $1\frac{1}{2}$ and 2 pairs of ions per cubic centimeter per second.

(2) Counting Tube.—invented 1928 by Geiger and Müller.

The number of ionizing rays is counted, each of which produces a whole train of ionized atoms. Rays which are simultaneous for the tube are counted as one.

Again only r-rays are directly detectable. A few simultaneously produced ions suffice to release a sudden discharge between a cylindricalmetal tube, in which the ions are produced, and an axial wire. The pulse is amplified and can be made to actuate a mechanical counter or other apparatus.

There are between 0.015 and 0.02 such ionizing rays per horizontal square centimeter per second at sea level.

(3) Wilson Cloud Chamber.—used 1929 by Skobelzyn.

Supersaturated water vapor condenses ions produced by passing r-ray, allowing path to be seen and photographed.

Here also only r-rays are directly detectable.

Strong magnetic fields (maximum about 20,000 gauss) have been used to deflect the rays. By photographing simultaneously the direct view and a reflection from an inclined mirror, the paths in three dimensions can be reproduced and the radius of curvature measured. From the latter the velocity and kinetic energy of the r-ray particle may be estimated if its mass and charge are assumed. The loss in energy in passing through a lead plate in the chamber may be determined from the change in curvature. Thus the positive electron was discovered, since the change in curvature gives the sense of travel as well.

(4) Combinations.

Coincidence counters or "cosmic ray telescope": two or more counter tubes with axes parallel and in the same plane can be electrically connected so that the counter will only be actuated when a ray goes through all tubes simultaneously. In this way only the rays coming from a given direction will be counted.

Coincidence counters and cloud chamber. The coincident pulse is made to release the expansion in a cloud chamber and operate the camera shutter, the chamber being placed in the same plane with the tubes. In this way the yield of cosmic ray track photos has been increased from 3–5% to over 70% of the whole number taken.

Coincidence counters with interposed absorbing matter have been used to get information about the penetrating power of cosmic rays. The interpretation of the results is still in dispute.

MEASUREMENTS

(1) Variation with altitude. Ionization measurements show a roughly exponential increase from about 0.0025 pairs of ions per cubic centimeter of normal air per second at depths of 240 meters of water (equivalent to 18 meters Hg), to 1.5 or 2 at sea level, to about 300 at heights corresponding to 18 millimeters Hg atmospheric pressure.

(2) Variation with latitude. A decrease of 12 to 18% is found at the equator compared to values at latitudes 50°–90°.

(3) Variation with direction.

More rays come from the west than from the east in places where the latitude effect (2) is appreciable. The effect increases with altitude and with proximity to the equator.

(4) Many other characteristics and properties of cosmic rays have been studied by the means mentioned above with a view to determining the nature of the *ultimate* cause of the r-rays which are only the directly observed quantities.

INTERPRETATIONS

There are two principle intepretations concerning the ultimate nature of cosmic rays.

(1) Corpuscular Theory (Particles). (A. H. Compton)

According to this view the cosmic radiation reaching the earth consists mainly of r-rays with energies ranging as high as 10^{10} or even 10^{11} electron volts. The latitude and direction variations cited support this view. Compton has recently (*Physical Reqiew*, April 1, 1934) drawn evidence for it from the altitude variation as well. The predominance of rays from the west indicates a positive charge predominance in the magnetically deflectable cosmic r-rays. Experiments with absorbing material interposed between coincidence counters are believed to support this theory also.

Uncertainties arise because such high energy particles cannot be studied in any other way for comparison, because the incoming energy distribution may be quite arbitrary, because such high energy particles must produce

very hard X-rays (photons) when they impinge on atoms, which in turn would give rise to secondary r-rays, etc.

(2) Wave Theory (Photons). (R. A. Millikan)

According to this view the cosmic radiation reaching the earth consists mainly of electromagnetic waves of very short wave lengths, and energies up to 3×10^9 electron volts per photon at the most. The r-rays which affect the measuring apparatus are interpreted as being secondary rays produced when these high energy photons impinge upon atoms. Support for this view was obtained from the general trend of the altitude variation curve, and from the energies of the r-rays as measured in cloud chamber methods.

Uncertainties arise here also because such high energy photons cannot be studied in any other way for comparison, because the incoming energy spectrum may also be quite arbitrary, because the secondary r-ray particles may qualitatively at least produce all the phenomena of the corpuscular theory. Exceptions to this are seen by many physicists in the theory's inability to account adequately for the latitude and direction variations cited.

Further investigation must decide between the two theories. It may turn out that appreciable parts of the cosmic radiation consist of particles and of photons, with the possible addition of neutrons or further unknown particles.

DETERMINATION OF STRESS DISTRIBUTION IN ENGINEERING MATERIALS BY MEANS OF THE PHOTO-ELASTIC METHOD

By Dr. M. L. Price
Worcester Polytechnic Institute

Due to the high speed and intricate design of present day machinery, it has become of increasing importance that engineers and designers have a fair knowledge as to the exact manner in which stresses are distributed throughout structures or machines that are subjected to given operating conditions. Most failures in structures and machines can be traced to the breaking down of a portion of the mechanism where, due to poor or improper design, stresses had become concentrated or localized.

The exact way in which a material behaves under various conditions of of loading can, in a few simple cases, be determined by mathematical analysis. However, for most practical cases such a mathematical analysis would at the very best be very cumbersome if not impossible entirely and for this reason most machines have been designed by use of empirical formulae which have been derived after years of practice in the building of similar machines. In many cases empirical formulae are not entirely satisfactory for the design of machines that are to be operated at much higher speed than those for which the formulae were first derived. In such cases it has been the practice either to build up a full scale model of the mechanism or structure and then determine whether or not thedesign was of the

proper sort to allow safe operation under extreme conditions. In other instances small scale models have been constructed and then tested in various ways to determine the degree of satisfaction resulting from the particular design used in its construction. Subsequent models might thus be designed in which any undesirable features might be eliminated.

Another way of investigating the behavior of mechanisms under action of various loading conditions consists of making up a small scale model of the structural or machine element from some transparent material such as celluloid, bakelite, or any other material possessing the desired characteristics and then subjecting these models to conditions of load similar to those under which the full scale model is to operate.

Under action of stress and strain the transparent material takes on unusual optical properties in that it becomes doubly refracting. The temporarily changed properties of the material can be detected and measured by means of an optical arrangement known as a polariscope. The effect upon the optical properties of the material is known to be directly proportional to the maximum shearing stress set up in the material. Points of equal stress intensity produce the same effect upon light passed through the model by means of the polariscope and the optical arrangement is designed so as to reveal these points to the naked eye in the form of color bands which traverse the model in fascinating patterns. The magnitudes and directions in which these stresses act can be quite accurately and easily determined. For class-room demonstration the image of the model can be thrown onto a screen.

It is known that the stresses distribute themselves through the material in accordance to the shape and size of the structure and according to the manner in which the loads are placed on the structural or machine element. It is further known that the distribution of the stresses is independent of the kind of material, hence it is possible to use transparent materials and then transpose the results so as to make them valid for steel, concrete, wood, or any other of the common types of building materials.

NEW APPARATUS FOR LECTURE DEMONSTRATION OF WAVE FORMS OF ALTERNATING CURRENTS

By Prof. H. H. Newell
Worcester Polytechnic Institute

The laboratory study of the phenomena occurring in alternating current circuits has for many years been facilitated by the use of the oscillograph. The use of the instrument to draw instantly the wave shapes as they occur has been found to add greatly to the student's sense of reality, even where the shapes can be readily plotted mathematically.

The difficulty of obtaining oscillographic apparatus suitable for viewing by a large group forced us to develop a machine especially suited to our needs. This machine, while following the general plan of other moving vane

oscillographs, has been built with larger elements and mirrors, to permit sufficient light to be transmitted for use on a large screen. This admittedly entails some sacrifice in precision, but at an early stage in instruction this lack is not serious.

A feature which we find of particular value is the element showing the variation of power consumed in the circuit. The action of an alternating current motor, for example, can thus be shown in some detail, the increase in current and power, and change in phase relations, as the mechanical load is increased, being readily seen.

AFTERNOON

The entire afternoon was spent in a visit to the Alden Hydraulic Laboratory at Chaffins. This is under the direction of Prof. Charles M. Allen.

Here on a tract of 110 acres are reservoirs, pipe lines, shops, mess hall and laboratories with machines and instruments of all types necessary to the hydraulic engineer.

Not only does this plant serve as a training school for students from Worcester Polytechnic Institute but the grounds contain many complete models of hydro-electric developments in New England, New York, on the Columbia River and elsewhere.

The studies carried out with these working models enable the actual installation of the plant to be made with many savings in construction and with certainty of results.

Prof. Allen gave us every opportunity to see the equipment and to have its operation explained to us and then very hospitably invited us for refreshments to his charming home on an elevation overlooking the laboratory grounds.

It is impossible to present in a printed report the story of the afternoon's experiences. The secretary repeats what he has tried to emphasize before an numerous occasions. Members who seldom attend the meetings should realize that they are not receiving full value from their association. The possibilities of visiting plants and laboratories not open to the general public and of having one's questions answered by eminent experts are phases of the work of the association which members cannot afford to miss.

PROBLEM DEPARTMENT

Conducted by G. H. Jamison
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1332. *Ralph Newman, Fayetteville, Arkansas.*

1334. *Proposed by Cecil B. Read, Wichita, Kan.*

Given the simultaneous equations

$$x^2+y=7 \quad (1)$$

$$y^2+x=11 \quad (2)$$

Obtain a solution giving all values for x and y, without the necessity of solving any equation of degree higher than two.

The exact solution of this problem is impossible. E. B. Escott, Oak Park, Illinois, gives a method for securing approximate solution by successive trials. W. E. Buker, Leetsdale, Pa., and Norman Anning, University of Michigan, contributed several references to the problem which follow.

American Mathematical Monthly, V. 6, p. 13; V. 7, p. 169 and V. 10, p. 192 and Finkel's *Mathematical Solution Book*, p. 475.

1335. *Proposed by W. E. Buker, Leetsdale, Pa.*

In a shuffled pack of 52 cards, what is the probability that a four and seven, for example, will be next to each other provided it is known that there is no four or seven among the first four cards.

W. R. Smith, Lewis Institute, Chicago, submits three solutions to the problem.

In a deck of 48 cards containing 4 fours and 4 sevens there are 47 sequences of two cards of which any sequence may be 4–7.

Chance that 1st card of a given sequence may be $4=\frac{4}{48}$.

Chance that next card will be $7=\frac{4}{47}$.

Chance that given sequence will be $4—7=\frac{4\times4}{48\times47}$.

Chance that sequence 4–7 will occur $=47\times\frac{4\times4}{48\times47}=\frac{1}{3}$.

Chance that sequence 7–4 will occur is same.

Therefore, total chances $=\frac{2}{3}$.

Again chance that 4 Spades will be in one of first 47 positions is $\frac{47}{48}$.

Chance that 7 Spades will follow it is $\frac{1}{47}$.

Chance that 4 Spades will be followed by 7 Spades is $\frac{1}{48}$.

Chance that 4 Spades will be followed by 7 spot is $\frac{4}{48}$.

Chance that 4 spot will be followed by 7 spot is $\frac{16}{48}=\frac{1}{3}$.

Chance that 7 spot will be followed by 4 spot is same

Therefore total chances $=\frac{2}{3}$.

Again there are 46 positions in which a 4 may have 7 before or after it. There are 2 positions in which a 4 may have 7 on one side only.

Chance that a given 4 will be in one of 46 positions is $\frac{46}{48}$.

Chance that it will be followed or preceded by 7 is $\frac{8}{48}$.

Chance that it will be followed or preceeded by 7 in some one of 46 positions is $\frac{8\times 46}{48\times 47}$.

Chance that a given 4 will be in one of end positions is $\frac{2}{48}$.

Chance that there will be a 7 next to it is $\frac{4}{47}$.

Chance that there will be a 4 in an end position with a 7 next to it is $\frac{2\times 4}{47\times 48}$.

Chance that a given 4 will have a 7 next to it is $\frac{2\times 4}{47\times 48}+\frac{8\times 46}{47\times 48}=\frac{1}{6}$.

As there are four fours, total chances $=\frac{1}{6}\times 4=\frac{2}{3}$.

1336. *Proposed by Charles W. Trigg, Los Angeles, California.*

A horse is tethered by a 50 ft. rope to a ring fixed 30 ft. from the ground in the wall of a cylindrical silo, 20 ft. in diameter. Over what area can it graze?

Solution by Boris Garfinkel, Buffalo, New York

The problem can be reduced to two dimensions by projecting the rope on the plane of the ground. The required area is bounded by a curve which may be viewed as generated by the free end P of a taut rope of length $1=\sqrt{50^2-30^2}=40$ ft., whose fixed end c' is located on a circle of radius $a=10$ ft. Since $1>a\pi$, the two branches of the curve overlap. The area $BCDB$, on one side of the axis of symmetry BD can be analyzed into its component parts.

Let A_1 be the area $OBCO$ swept by OP, the radius vector of the involute of the circle O. The parametric equations of the curve referred to polar axis OA are:

$$r=a\sqrt{1+\phi^2} \tag{1}$$

$$\theta=\phi-\tan^{-1}\phi \text{ where } \phi=\angle AOP' \tag{2}$$

$$\therefore\quad A_1=\frac{1}{2}\int_{\theta_1}^{\theta_2} r^2d\theta=\frac{1}{2}\int_{\phi_1}^{\phi_2} a^2\phi^2d\phi=\frac{1}{6}a^2\phi\Big]_{-\phi_1}^{\phi_2}.$$

The upper limit of integration, $\phi_2=\angle AOC'$, is found by setting $a\phi=l$,

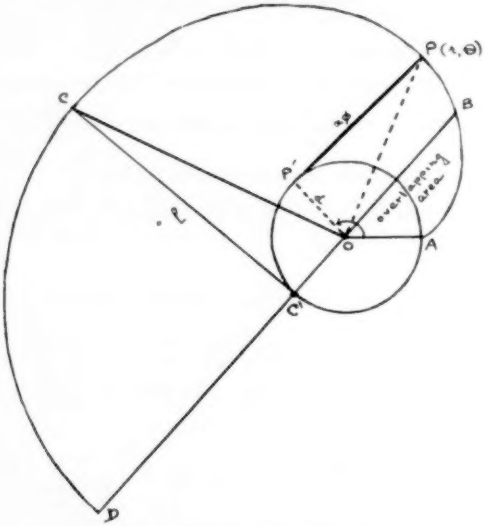
whence $\phi_2=l/a=4$. The lower limit ϕ_1 is determined by substituting $\theta_1=\phi_2-\pi$ in equation (2) whence

$$\phi_1-\tan^{-1}\phi_1=\phi_2-\pi=4-\pi=0.8584.$$

Solution by approximation yields $\phi_1=1.957$.

A_2, the area of the right triangle $OC'C$, equals $\frac{1}{2}al$.

A_3, the area of the quadrant $CC'D$, equals $\frac{1}{4}\pi 1^2$.



The total grazing area A is found by doubling the sum $(A_1+A_2+A_3)$ and deducting πa^2, the area of circle O.

$$\therefore\quad A=\frac{1}{3}a^2\phi^3\Big]_{-\phi_1}^{-\phi_2}+al+\frac{1}{2}\pi l^2-\pi a^2.$$

Substituting $a=10$, $1=40$, $\phi=1.957$, $\phi_2=4$ gives $A=4482.6$ sq. ft.

Other solutions were submitted by Warren R. Smith, Chicago. and A. W. Randall, Prairie View, Texas.

1337. *Proposed by the Editor.*

The line connecting the intersection of the non-parallel sides of a trapezoid, and the intersection of the diagonals passes through the mid-point of the shorter parallel side.

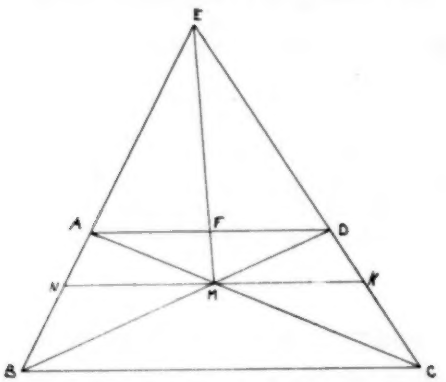
Given: Trapezoid $ABCD$, BA and CD intersect at B. Diagonals AC and BD intersect at M. EM cuts AD in F.

To Prove: $AF=FD$

Proof:

1. Draw NK parallel to AD and passing through M.
2. $NM:AD=BN:BA$ and also $MK:AD=KC:DC$.
3. $BN:BA=KC:DC$. Therefore
4. $NM:AD=MK:AD$ from which $NM=MK$
5. $AF:NM=FE:ME$ and also $FD:MK=FE:ME$. Therefore
6. $AF:NM=FD:MK$ since $NM=MK$
7. $AF=FD$.

In similar manner it follows that EM extended bisects BC.



Also solved by W. E. Buker, Leetsdale, Pa., and Charles W. Trigg, Los Angeles and Maxwell Reade, Brooklyn, New York.

1338. *Proposed by Roy MacKay, Albuquerque, New Mexico.*

If P is a point on the Euler Line of the triangle $A_1A_2A_3$ one-kth of the distance from the circumcenter to the orthocenter,

$$PA_i^2=\{R^2(k-3)^2+(a_j^2+a_k^2)(k-1)-a_i^2\}/k^2,$$

where a_i is the side opposite A_i and R is the circumradius of the triangle $A_1A_2A_3$.

Solution by Proposer

Denote the circumcenter and the orthocenter of the triangle by O and H, respectively. Then

(1) $$HA_i^2=PH^2+PA_i^2-2PH\cdot PA_i\cos HPA_i,$$

and

(2) $$OA_i^2=OP^2+PA_i^2-2OP\cdot PA_i\cos OPA_i.$$

Now angles HPA_i and OPA_i are supplementary (or equal), and $HA_i^2=4R^2-a_i^2$; $OA_i^2=R^2$; $PH=(k-1)OP=OH(k-1)/k$; $OH^2=9R^2-a_1^2-a_2^2-a_3^2$.

Multiplying (2) by $k-1$ and adding to (1) (or subtracting) gives, after substituting and rearranging,

$$k^2PA_i^2=R^2(k^2+3k)-ka_i^2-(k-1)(9R^2-a_1^2-a_2^2-a_3^2).$$

Simplifying this last expression and dividing both members by k^2, the desired formula results.

NOTE: *The reader may find references to results used in this solution to Johnson's Modern Geometry, pages 70, 163 and 165.*—EDITOR

Also solved by W. E. Buker, Leetsdale, Pa., and Norman Anning, University of Michigan.

1339. *Proposed by the Editor.*

Three numbers are in geometric progression. If 3 is added to the first, 2 to each of the 2d and 3d, the resulting numbers are in arithmetic progression.

Solved by E. B. Escott, Chicago

Let the three numbers be x/y, x, xy.

Then $x/y+3$, $x+2$, $xy+2$, are in arithmetic progression from which it follows that $2(x+2)=x/y+3+xy+2$.

Hence $x=-y/(y-1)^2$. Then the required numbers are:

$$-\frac{1}{(y-1)^2},\quad -\frac{y}{(y-1)^2},\quad -\frac{y^2}{(y-1)^2}$$

where y is any number except 0 or 1.

Also solved by Charles W. Trigg, Los Angeles; Maxwell Reade, Brooklyn, N. Y.; Herman O. Masky, Fort Wayne, Indiana; J. O. Austin, Cowden, Ill.; and A. W. Randall, Prairie View, Texas.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below.

1330. Virginia Martinez and Edna Rucker, Benson, Arizona, High School; and David Blackwell, Centralia, Illinois.

1339. William Kent, Lewis and Clark High School, Spokane, Washington; H. Hanson Smith, Battle Creek, Iowa; William Gross, Leetsdale, Pa.; and Henry Luster, Simon Gratz H. S., Philadelphia, Pa.

1352. *Proposed by Harry Frye, Tullahoma, Tenn.*

The circumference of a circle is divided into ten equal divisions with division points connected by lines through the center. The points of division are numbered clockwise as follows: 1-10-3-6-7-2-9-4-5-8. The sum of the numbers for any two adjacent points equals the sum of the two opposite numbers.

Using the same device, number the points so that the difference of any two adjacent numbers equals the difference of the opposite numbers.

PROBLEMS PROPOSED FOR SOLUTION

1353. *Proposed by B. Felix John, Pittsburg.*

Given $2\sin^2\theta-\sin\alpha=1$, prove $\theta=\pi/2+\pi\alpha/4$.

1354. *Proposed by Norman Anning, University of Michigan.*

Prove that it is impossible to choose real angles A, B, C, so that $\cos A\cos B+\cos B\cos C+\cos C\cos A$ may be less than -1.

1355. *Proposed by William Roth, East St. Louis, Missouri.*

Of three cevians of a triangle one is an altitude. Prove that the altitude bisects the angle formed by the lines drawn from the foot of the altitude to the points where the other cevians meet the sides of the triangle.

1356. *Proposed by Charles P. Louthan, Columbus, Ohio.*

In a right triangle if the base is a mean proportional between the hypotenuse and altitude, express the area, the length of the base and altitude in terms of the hypotenuse.

1357. *Proposed by Charles W. Trigg, Los Angeles, California.*

Each of the first n terms of the A. P., $a, a+d, a+2d, \cdots$ is multiplied by the corresponding term of the G. P., $b, br, br^2, \cdots$, which also contains n terms. Find the sum of the first n terms of the resulting series.

BIOLOGICAL TERMS

By ARTHUR H. BRYAN, *Baltimore City College*

Nomenclature required of students taking minimum requirement course in biology in the Baltimore City College.

1. Absorption
2. Acquired immunity
3. Adventitious roots
4. Algae
5. Alternation of Generations
   - Mosses
   - Ferns
6. Amphibian (frog)
7. Angiosperms
8. Annulata
9. Antheridia
10. Anthrax
11. Antiseptic
12. Antitoxin
13. Aquatic roots
14. Arteries
15. Artificial pollinatino
16. Archigonia
17. Arthropoda
18. Artificial selection
19. Assimilation

20. Bacteria
21. Binary fission
    - Amoeba
    - Paramoecium
    - Bacteria
22. Biology
23. Botany
24. Bracket fungi
25. Bryophyte
26. Bud
27. Blood Corpuscles

28. Cambium
29. Canine
30. Capillaries
31. Carbohydrates
32. Cell
33. Cestode
34. Cloaca
35. Colony
36. Combustion
37. Compound
38. Co-ordination
39. Conjugation
40. Contractile vacuole
41. Coelenterata
42. Corolla
43. Cortex
44. Crustacea
45. Cytoplasm

46. Diaphragm
47. Dicotyledenous stem
48. Digestion
49. Disinfectant

50. Echinodermata
51. Element
52. Embryo
53. Endosperm
54. Entomology
55. Environment
56. Equine
57. Enzyme
58. Epidermis of leaf
59. Excretion

60. Fertile soil
61. Fertilization
62. Fruit
63. Function

64. Geotropism
65. Grafting
66. Gymnosperms

67. Heredity
68. Hexapoda
69. Hepaticae
70. Hibernating animal
71. Hilum
72. Hydrotropism
73. Hypocotyl

74. Immunity
75. Infusoria

76. Legumes
77. Lichens
78. Lymph

79. Malaria
80. Mammals
81. Medullary rays

82. Membrane
83. Measles
84. Metamorphosis
85. Micropyle
86. Mildew
87. Milt
88. Mimicry
89. Mitosis
90. Monocotyledenous stem
91. Molluska
92. Motor nerves
93. Musci
94. Mushrooms
95. Myriapoda

96. Narcotic
97. Nemahelminthes
98. Nematode
99. Nitrogen cycle
100. Nucleus
101. Nutrients

102. Organism
103. Ophidia
104. Ornithology
105. Osmosis
106. Ovary
107. Oxidation
108. Parasitic bacteria
109. Pasteurization
110. Peristalsis
111. Petal
112. Petiole
113. Petri dish
114. Phloem cells
115. Photosynthesis
116. Physiology, human
117. Pisces
118. Pistil
119. Pith
120. Pollen
121. Platyhelminthes
122. Pneumonia
123. Porifera
124. Primary root
125. Protective coloration
126. Protective resemblance
127. Proteins
128. Protoplasm
129. Protozoa
130. Pruning
131. Pteridophyte
132. Pure culture

133. Quarantine

134. Radiolaria
135. Regeneration
136. Rana
137. Reproduction
138. Reptillia
139. Respiration
140. Rhizopoda
141. Root cap
142. Root hairs
143. Ruminants

144. Saprophytic bacteria
145. Scavengers
146. Schick test
147. Secondary roots
148. Seed dispersal
149. Sensory nerves
150. Sepals
151. Spore
152. Sporozoa
153. Spermary
154. Spawning
155. Stamen
156. Stigma
157. Stomata
158. Style
159. Symbiosis

160. Tap root
161. Teleats
162. Testa
163. Tissue
164. Transpiration
165. Tuberculosis
166. Typhoid

167. Ungulata

168. Vaccination
169. Vacuole
170. Venine
171. Vitamins
172. Vermes

173. Xylem

174. Yeasts

175. Zoology
176. Zygospore

SCIENCE QUESTIONS

October, 1934

Conducted by Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio

Readers are invited to co-operate by proposing questions for discussion and problems for solution.

Examination papers, tests, and interesting scientific happenings are very much desired. Please enclose material in an envelope and mail to Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio.

GQRA

(Guild of Question Raisers and Answerers)

You become a member when you send in a question, or an examination paper, or a test, or an answer that is published.

In the year just past (1933–34) thirty-nine individuals or groups qualified. A number of classes sent in questions they were discussing or answered questions brought up by others.

Have your class answer or propose a question.

668. *Proposed by Walter E. Hauswald, GQRA #2, Beardstown High School, Beardstown, Ill.*

An iron pipe ten miles long and seven feet in diameter is placed on the earth so that it is in a perfectly straight line parallel to a tangent to the earth at the midpoint of the pipe's length.

This pipe is closed at both ends and is filled with water. When the ends are opened less than half the water will run out. Why?

ANOTHER MONKEY PROBLEM

B. Felix John has sent the *Editor* another "monkey problem." If you want it published, write at once and say so to the Editor of Science Questions, 10109 Wilbur Avenue, Cleveland, Ohio.

WHY PUPILS FAIL

643. *W. F. Roecker submitted a list of "too easy" questions on which too many pupils fail published in the February, 1934, number of* School Science and Mathematics.

Regarding No. 643. By Carlton D. Blanchard, (GQRA #30) Norwich Free Academy, Norwich, Conn.

This question has interested me because I have been perplexed with the results of exams which I thought should be easy but which in fact have proven too difficult with more than one class.

It seems to me that there are several ways in which this test could be used to "separate the gold from the dross." I shall take these up in order.

I—The fact that the examination "invariably fails more people than it should" and has been used several times indicates that *what the pupils have retained* from their instruction and laboratory work is not the same something which the *teacher thought the pupils should have retained* but which in fact (borne out by the results of several tests) the pupils *have not* retained.

In my experience I find that pupils rarely fail in great numbers on memory items. Of the first 25 questions there are a great many which require logical reasoning in addition to the factual material. This is where the average pupil falls down on the test, or rather *where the test falls down* by

not considering fully enough the immaturity of the average pupil in grades 11 and 12. Suggest more questions (say 40) including more memory items.

II—The method of scoring is highly important. The value of the first twenty-five questions could be increased to 3 points each, and the problems counted 5 points each. A good deal would depend upon how much partial credit is given on the problem work.

III—The third suggestion is to score the examination on *what the pupils did* and not on *what the teacher thinks the pupils should have done.* That is, grade the papers on the median basis. I do this in all of my work now. For example, after I have corrected a set of examination papers on a uniform credit basis, I arrange the papers in order of rank. The median is then selected and, if found to be low, it is automatically raised to a 70, 75, or 80. One must remember that marks are only arbitrary things at best, and should indicate the ability of pupils in comparison with fellow pupils. Some teachers may consider this last method unfair or unscientific. It depends upon one's definition of a test or examination, i.e., Should a test be a device to discover what pupils have retained or what some one else *thinks* they should have retained?

Hope my reactions may be of some help.

SOME MORE TOO EASY PROBLEMS

In May, 1934, Questions 654–655–656–657 and 658 repeated Roecker's Questions 1–5 (February, 1934, S. S. & M.).

Here are a few more of these "too easy" questions.

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669. (6) When a cubic foot of water is warmed 1 degree Fahrenheit how many BTU are needed?

---

670. (7) The vacuum in a thermos bottle does not prevent heat transfer by ....

---

671. (8) What is the reading of absolute zero on the centigrade scale?

---

672. (9) A boat weighing 625 pounds displaces how much water?

---

673. (10) The center of gravity of a vase is .... when flowers are put into it.

Mr. Blanchard has expressed his opinion on the reasons "Why Pupils Fail." What do you think about it?

Join the G.Q.R.A.

EXPERIMENTAL PROJECTS IN GENERAL SCIENCE

674. *Proposed by Arnold Bookheim, GQRA #36, Williamson Central School, Williamson, N. Y.*

These projects were tried as experiments in Eighth Grade General

Science with fair success. Their scope is not great, only the barest essentials are covered in each case, details being left for courses in Physics and Chemistry. All work was done only during class periods. Differences of ability are provided for by including optional work.

They help develop a sense of responsibility and a knowledge of the use of scientific references and scientific apparatus.

GENERAL SCIENCE PROJECT—HYDROGEN

The answers to the following questions may all be obtained *by looking in text books, reference books,* or *the files in the library.* However, the answers to those questions marked with an E can also be found by experiment. If you wish to perform the experiments ask your teacher to supply you with the apparatus and materials necessary.

Minimum assignment—all questions except those marked (opt.) optional. No experiment. Highest possible mark—80%.

Medium assignment—all questions or required questions and experiment. Highest possible mark—90%.

Maximum assignment—all questions and experiment. Highest mark—100%. (N.B. means use note book paper.)

Name.................... Check Opt. Questions Experiment

1. What is the chemical symbol for hydrogen? ....

1a. (opt.) Where is hydrogen found in nature?

E2. How is hydrogen made in the laboratory?

2a. (opt.) Write a chemical equation in words to represent the preparation of hydrogen in the laboratory.

2b. (opt.) Write the same equation in chemical symbols.

E3. Does hydrogen have any color? ....

E4. Does hydrogen have any taste? ....

E5. Does hydrogen have any odor? ....

E6. Does hydrogen dissolve in water? ....

E7. Is hydrogen heavier or lighter than air? ....

E8. Does hydrogen burn? ....

E9. What happens when hydrogen is mixed with an equal volume of air and the temperature then raised to its kindling point?

10. What would you use as a test for hydrogen?

11. State two uses of hydrogen.

12. Upon what property of hydrogen does its most important use depend?

13. (opt.) The "Graf Zeppelin" uses hydrogen to keep it afloat. How many times has the "Graf Zeppelin" crossed the Atlantic ocean? ....

14. (opt.) By what commercial method is the hydrogen used in the Graf Zeppelin made?

15. (opt.) If hydrogen is the lightest gas known and is used in the Graf Zeppelin, why is helium, which is not as light as hydrogen, used in the U.S.S. Macon, the biggest airship in the world?

16. (opt.) What gas did Commander Settle use for his recent record-breaking balloon flight into the stratosphere? ....

How high did he go? ....

Who first ascended into the stratosphere? ....

What country claims the altitude record for such a flight? ....

What gas, other than hydrogen, that you have studied, was used during these flights? .... Why?

17. You are given a bottle and told it contains one of the following gases: oxygen, hydrogen, nitrogen, or carbon dioxide. You are asked to tell which gas you have. Describe *in detail* the procedure you would follow. (Suggestion—Which gas would you test for first? Why?)

R U IN THE GQRA

BOOKS RECEIVED

Introductory Course in Science for Colleges: Volume I, Man and the Nature of His Physical Universe. Pages x+524. Volume II, Man and the Nature of His Biological World. Pages ix+589. By Frank Covert Jean, Ezra Clarence Harrah, and Fred Louis Herman, Colorado State Teachers College with the Editorial Collaboration of Samuel Ralph Powers, Teachers College, Columbia University. Cloth. 14×20.5 cm. 1934. Ginn and Company, 15 Ashburton Place, Boston, Massachusetts. Price $2.20 each.

A Textbook of General Botany for Colleges and Universities, by Richard M. Holman, Associate Professor of Botany in the College of Letters and Science of the University of California, and Wilfred W. Robbins, Professor of Botany in the College of Agriculture of the University of California. Third Edition. Cloth. Pages xv+626. 15×23 cm. 1934. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $4.00.

Solid Mensuration, by Willis F. Kern, Instructor of Mathematics at the U. S. Naval Academy, and James R. Bland, Assistant Professor of Mathematics at the U. S. Naval Academy. Paper. Pages v+73. 14×21.5 cm. 1934. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $1.25 plus postage.

Analytic Geometry, by Frederick S. Nowlan, Professor of Mathematics, The University of British Columbia. Second Edition. Cloth. Pages xii +353. 12.5×18.5 cm. 1934. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $2.25.

The Endless Quest, Three Thousand Years of Science, by F. W. Westaway, Author of "Scientific Method; its Philosophic Basis and its Modes of Application"; "Science and Theology: Some Common Aims and Methods" etc. Cloth. Pages xix+1080. 14.5×22 cm. 1934. Blackie and Son Limited, 50 Old Bailey, London. Price 21s. net.

Hygiene and Home Nursing, A Practical Text for Girls and Women, by Louisa C. Lippitt, Instructor in the Training Schools at Children's and Homeopathic Hospitals in Washington, Formerly Department of Physical Education, University of Wisconsin. Illustrated. Cloth. Pages viii+424. 12×18.5 cm. 1934. World Book Company, Yonkers, New York. Price $1.24.

A Textbook of Organic Chemistry, by Joseph Scudder Chamberlain, Professor of Organic Chemistry, Massachusetts State College. Third Edition. Cloth. Pages xxv+873. 14×21. 1934. P. Blakiston's Son and Co., Inc., 1012 Walnut Street, Philadelphia, Pa. Price $4.00.

Entomology With Special Reference to Its Ecological Aspects, by Justus Watson Folsom, Senior Entomologist, U. S. Bureau of Entomology. Revised by R. A. Wardle, Professor of Zoology, University of Manitoba, Winnipeg, Canada. Fourth Edition. Cloth. Pages ix+605. 14.5×22 cm. 1934. P. Blakiston's Son and Co., Inc., 1012 Walnut Street, Philadelphia, Pa. Price $4.00.

Essentials of Plane Trigonometry and Analytic Geometry, by Atherton H. Sprague, Associate Professor of Mathematics, Amherst College. Cloth. Pages x+228. 14.5×23 cm. 1934. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price $1.80.

Plane and Spherical Trigonometry, by Claude Irwin Palmer, Late Professor of Mathematics and Dean of Students, Armour Institute of Technology, and Charles Wilber Leigh, Professor of Analytic Mechanics, Armour Institute of Technology. Fourth Edition. Cloth. Pages xiv+229. 14×23 cm. 1934. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $1.50.

Applied Acoustics, by Harry F. Olson, Research Laboratories, RCA Victor Company, Inc., and Frank Massa, Research Laboratories, RCA Victor Company, Inc. 228 Illustrations. Cloth. Pages xiv+430. 14×21 cm. 1934. P. Blakiston's Son and Co., Inc., 1012 Walnut Street, Philadelphia, Pa. Price $4.50.

This Changing World, by Samuel Ralph Powers, Professor of Natural Sciences, Teachers College, Columbia University; Elsie Flint Neuner, Supervisor of Elementary Science, New Rochelle, New York; and Herbert Bascom Bruner, Professor of Education, Teachers College, Columbia University. Cloth. Pages xiv+561. 13×20 cm. 1934. Ginn and Company, 15 Ashburton Place, Boston, Massachusetts. Price $1.40.

Physique, Classe de Première (Optique et Electricité), par M. Ginat, Ancien Élève de l'École Normale Superiéure, Professeur agrégé au Lycée du Havre. Board. Pages 485. 13×19 cm. 1934. J. B. Baillière and Sons, 19, rue Hautefeuille, 19, Paris.

Healthful Living, by Jesse Feiring Williams, Professor of Physical Education, Teachers College, Columbia University. Second Revised Edition. Cloth. Pages xv+622. 13×20 cm. 1934. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.56.

Tke Discovery of the Elements, by Mary Elvira Weeks, Assistant Professor of Chemistry at The University of Kansas. Illustrations collected by F. B. Dains, Professor of Chemistry at The University of Kansas. Second Edition Revised. Cloth. Pages iii+363. 15×23 cm. 1934. Mack Printing Company, Easton, Pa. Price $3.00.

The Professional Treatment of the Subject Matter of Arithmetic for Teacher-Training Institutions, Grades I to VI, by Elias A. Bond, Ph.D. Contribution to Education, No. 525. Cloth. 315 pages. 15×23 cm. 1934. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $2.50.

A First Course in Algebra, by N. J. Lennes. Cloth. Pages xii+456. 13×20. 1934. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.36.

Essentials of Plane Trigonometry, by Atherton H. Sprague, Associate Professor of Mathematics, Amherst College. Paper. Pages viii+124. 14.5×23 cm. 1934. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price 80 cents.

Work-Test Book to Accompany the New Edition Biology and Human Welfare, by James Edward Peabody, Recently Head of the Department of Biology. Morris High School, New York City. Paper. 158 pages. 20.5×28 cm. 1934. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price 40 cents.

A Unit Workbook in Plane Geometry, by F. Eugene Seymour, Supervisor of Mathematics, New York State Department of Education, Albany, N. Y., and Hallie S. Poole, Lafayette High School, Buffalo, N. Y. Paper. 126 pages. 20.5×28 cm. 1934. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price 40 cents.

Elementary Chemical Theory and Problems, by N. M. Shah, Department of Chemistry, Karnatak College, Dharwar, British India. Paper. Pages ii+145. 11×18.5 cm. 1933. The Karnatak Printing Works, Dharwar, British India.

The Prairie Province of Illinois, bv Edith Muriel Poggi. Illinois Studies in the Social Sciences, Vol. xix, No. 3. Paper. 124 pages. 17×26.5 cm. 1934. Published by the University of Illinois, Urbana, Ill. Price $1.00.

Sound, Hearing, and Music, An Experimental Teaching Unit, by Archer Willis Hurd, Institute of School Experimentation, Teachers College, Columbia University. Paper. 22 pages. 21.5×28 cm. 1934. Mimeographed at the Institute of School Experimentation, Teachers College, Columbia University, New York City.

Studies in College Examinations, by Committee on College Examinations. Melvin E. Haggerty, Dean of the College of Education, Chairman. Paper. Pages vii+204. 14.5×23 cm. 1934. The Committee on Educational Research, M. E. Haggerty, Chairman, University of Minnesota, Minneapolis, Minnesota.

Das Spiel Der 30 Bunten Würfel, von Ferdinand Winter, Dresden. Paper. 128 pages. 14×20 cm. 1934. B. G. Teubner, Leipzig. R.M. 3.60.

Wie Findet und Zeichnet Man Gradnetze von Land und Sternkarten? von Georg Scheffers, O. Prof. an der Technischen Hochschule Berlin. Paper. 98 pages. 11.5×18 cm. 1934. B. G. Teubner, Leipzig. R.M. 2.40.

The Deserted Village, Number 3, Power Alcohol and Farm Relief, by Leo M. Christensen, Ralph M. Hixon, and Ellis I. Fulmer, Department of Chemistry, Iowa State College, Ames, Iowa. Paper. 191 pages. 13×19 cm. 1934. The Chemical Foundation, Inc., 654 Madison Avenue, New York City.

Fusion Mathematics, by Aaron Freilich, Chairman, Department of Mathematics, Bushwick High School, Brooklyn, New York; Henry H. Shanholt, Chairman, Department of Mathematics, Abraham Lincoln High School, Brooklyn, New York; Joseph P. McCormack, Chairman, Department of Mathematics, Theodore Roosevelt High School, Bronx, New York. Cloth. Pages vii+600. 13×18.5 cm. 1934. Silver, Burdett and Company, 39 Division Street, Newark, New Jersey. Price $1.84.

Intermediate Algebra, by Aaron Freilich, Chairman, Department of Mathematics, Bushwick High School, Brooklyn, New York; Henry H. Shanholt, Chairman, Department of Mathematics, Abraham Lincoln High School, Brooklyn, New York; Joseph P. McCormack, Chairman, Department of Mathematics, Theodore Roosevelt High School, Bronx, New York. Cloth. Pages ix+406. 13×18.5 cm. 1934. Silver, Burdett and Company, 39 Division Street, Newark, New Jersey. Price $1.40.

Plane Trigonometry, by Aaron Freilich, Chairman, Department of Mathematics, Bushwick High School, Brooklyn, New York; Henry H. Shanholt, Chairman, Department of Mathematics, Abraham Lincoln High School, Brooklyn, New York; Joseph P. McCormack, Chairman, Department of Mathematics, Theodore Roosevelt High School, Bronx, New York. Cloth. Pages ix+293. 13×18.5 cm. 1934. Silver, Burdett and Company, 39 Division Street, Newark, New Jersey. Price $1.32.

Conservation Week in the Schools of New Jersey. A Manual for Teachers. Prepared by Miss Eva Gordon of the Department of Rural Education, Cornell University, under the direction of E. Laurence Palmer, Director of Nature Education for the American Nature Association Washington, D.C. and Professor of Rural Education, Cornell University, Ithaca, New York. Paper. 16 pages. 15×23 cm. 1934. Distributed by Department of Public Instruction, State of New Jersey. Price 5 cents.

Guided Steps in Arithmetic, by Henry Garland Bennett, President, Oklahoma Agricultural and Mechanical College; N. Conger, State Director of Teacher Training, Oklahoma; Gladys Pelton Conger, Former Teacher, Supervising Principal, and Critic Teacher. Cloth. 12×18 cm. First Steps, pages 391. Price 68 cents. Second Steps, pages 415. Price 72 cents. American Book Company, 330 East 22nd Street, Chicago, Ill.

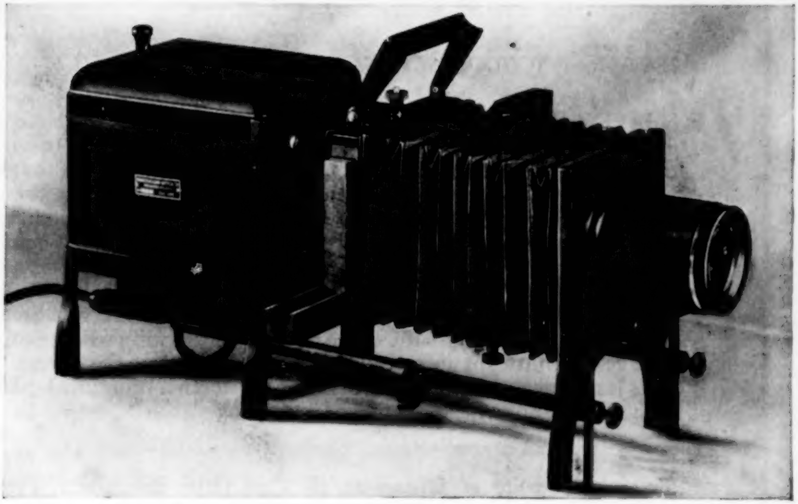
Super Calculation, by John R. Harold, 111 North Street, San Antonio Texas. Paper. Pages vi+108. 13×19 cm. 1931.

BOOK REVIEWS

The Story of Energy, by Morton Mott-Smith, Ph.D. Illustrated by Emil Kosa, Jr. First Edition. Cloth. Pages xii+305. 12.5×18.5 cm. 1934. D. Appleton-Century Company, New York, N. Y. Price $2.00.

The central theme of this little volume consists in the development of the idea of the conservation of energy. While the word "story" in the title has a certain appeal for the lay-reader, this volume is not a popularized treatment. The author has succeeded in giving an authoritative and concise picture in the simplest possible terms.

The first part of the book deals with the "Quest for Power" and centers around the development of steam power. The author gives a very concise analysis of the principle of the steam engine and cncludes this part with a discussion of the perfect gas cycle. From this point on the treatment is



both theoretical and philosophic. The advances made in the concept of energy center around the historical search for this invariant. In contrasting the work and method of Bacon and Mayer in one class with that of Joule, Helmholtz, and Clausius the author very carefully analyzes the methods of scientific research. The conservation idea finds its fulfillment in the work of Clausius and his statement of the laws of Thermodynamics. The author succeeds admirably in making the topic of Entropy somewhat intelligible.

While the author is not always conscious of his reader in treating the technical aspects of the subject, he succeeds in showing what revolutionary changes are brought in our idea of the universe by the energy concept. This last phase makes the work eminently worth a prominent place in the high school and college library.

C. RADIUS

Trees and Shrubs of Minnesota, by Carl Otto Rosendahl, Professor of Botany, and Frederic K. Butters, Associate Professor of Botany, University of Minnesota. Cloth. Pages vii+385. 17×25.5 cm. 1928. The University of Minnesota Press, Minneapolis, Minn. Price $4.00.

This is a fine book, one of the best. It differs from the usual type of tree book, by having fewer illustrations of the trees and shrubs from photographs and more line cuts of leaf, twig, flowers and fruit. It is printed on fine quality paper with unusually good type.

The book is based on the Minnesota trees and shrubs, but the distribution really extends from the Great Lakes to the Rocky mountains. In addition to the list of native trees and shrubs many cultivated plants are included with notes on their value for planting and ornament, in fact this feature is noted for all shrubs and trees.

The characteristics of the trees and shrubs described are carefully noted with respect to soil, water and climate. We cannot recommend this book too highly for use of secondary schools, colleges and the layman. It is the result of several years careful labor.

W. WHITNEY

Intermediate Algebra, by Aaron Freilich, Chairman, Department of Mathematics, Brunswick High School, Brooklyn, New York; Henry H. Shanholt, Chairman, Department of Mathematics, Abraham Lincoln High School, Brooklyn, New York; Joseph P. McCormack, Chairman, Department of Mathematics, Theodore Roosevelt High School, Bronx, New York. Pp. ix+406. Silver Burdette and Co., 1934, Price $1.40.

The reviewer sincerely feels that on the whole this book is just another algebra text for its arrangement is in conformity with the traditional algebras except that a chapter on numerical trigonometry has been inserted at the very beginning of the book. It is doubtful as to whether or not numerical trigonometry has a place in advanced algebra, especially when the student meets numerical trigonometry in his first course in algebra and again in plane geometry. The reviewer's experience with students has revealed that one introduction to the subject was sufficient because the second time the student is bored.

The authors have included short historical notes which should be helpful in the motivation of the pupil, but by failing to insert much pictorial material and large, clear graphs they have slighted a valuable way of arousing interest in mathematics. An abundance of graded problem material has been included under each topic.

G. L. ROYCE

Progressive First Algebra, by Walter W. Hart, Associate Professor of Mathematics, School of Education, and Teacher of Mathematics, Wisconsin High School, University of Wisconsin. Pp. vi+408. D. C. Heath & Co., 1934, Price $1.28.

Progressive Second Algebra, by Webster Wells and Walter W. Hart. Pp. v+298. D. C. Heath & Co., 1934, Price $1.32. Either of these texts may be had with or without answers at the same price.

In *Progressive First Algebra*, Mr. Hart has produced a text which should fill the needs of many teachers of mathematics. It is truly a modern text for in it you will find (1) a wealth of problem material with provision for different abilities; (2) plenty of pictures to motivate the pupil; (3) diagnostic tests, chapter mastery tests, comprehensive tests, and (4) reviews. Equations are introduced in the early pages of the text and constantly extended through application to each new topic. Graphs are emphasized throughout as an instructional means.

In *Progressive Second Algebra*, the authors have followed the plan of the first book in this series. In the first seven chapters the authors have included a complete review of the first course. However, the instruction is expansive in order to compensate for the simplification which has generally taken place in the first course in algebra. It might be well to remark that it is possible to use the second book independent of the first.

G. L. Royce

MEASURING THE DISTANCE FROM MIRROR TO SCALE ON THE D'ARSONVAL GALVANOMETER

Julian L. Thompson
Broadview Junior College, La Grange, Illinois

When using a D'Arsonval galvanometer with telescope and scale as a deflection instrument, it is necessary to know the mirror-scale distance. If the front glass of the galvanometer cannot be removed, a simple parallax method will determine the distance from the front glass to the mirror. This added to the distance from the glass to the scale gives the required mirror to scale distance.

A pin or other suitable pointer is supported in front of the galvanometer, and its image in the glass (not in the mirror) is located. By adjustment of the pointer, this image is made to appear tangent to the mirror when viewed from directly in front. A back and forth adjustment of the pointer will give a position for which the image remains just on the edge of the mirror as the head is moved from side to side, moving neither onto nor away from the mirror. The image is then the same distance back of the glass as is the mirror. Since the distance from image to glass is the same as the distance from pointer to glass, the easily measurable distance from the pointer to the glass gives the distance from mirror to glass. This assumes of course that the front glass is flat, a condition usually well enough approximated to be practical.

CLEFTS OR "CANALS" DISCOVERED ON MOON

"Ditch-like," straight line depressions on the surface of the moon are exciting the interest of astronomers.

"Canals," some observers have been tempted to call them, by analogy with the famous and oft-disputed markings on the planet Mars.